Shire of Serpentine Jarradale

Lots 1 & 2 Rowley Road Structure Plan

May 2020 | 19-588

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the art and science of place

This structure plan is prepared under the provisions of the Shire of Serpentine-Jarrahdale Town Planning Scheme No. 2.

IT IS CERTIFIED THAT THIS STRUCTURE PLAN WAS APPROVED BY RESOLUTION OF THE WESTERN AUSTRALIAN PLANNING COMMISSION ON:

June 2012

In accordance with Schedule 2, Part 4, Clause 28 (2) and refer to Part 1, 2. (b) of the *Planning and Development (Local Planning Schemes) Regulations 2015.*

Date of Expiry: 19 October 2030

We acknowledge the custodians of this land, the Whadjuk (Perth region) Noongar and their Elders past, present and emerging. We wish to acknowledge and respect their continuing culture and the contribution they make to the life of this city and this region.

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Issue	Date	Status	Prepared by	Approved by
1	05.05.20	Draft	Justin Page	Murray Casselton
2	20.08.2020	Final	Justin Page	Murray Casselton

Contents

Table of Amendments to Structure Plan

Amendment No.	Description of Amendment	Date Endorsed by Council	Date Endorsed by WAPC
1	Structure Plan amendments: • Increase in public open space; • Removal of 'Grouped Housing' notation for large lots in NW & NE corner; and • Modification to road layout.	23/05/2016	27/06/2016
2	Structure Plan amendment: • Re-code portion of structure plan from R40 to R20.	-	21/10/2021

Forward Note

The *Lots 1 & 2 Rowley Road Structure Plan* was initially approved by the Western Australian Planning Commission in June 2012. Amendment No. 1 to the structure plan was endorsed by the Commission on 27 June 2016. Therefore, please note the structure of this document is as follows:

- **Part one:** Implementation including latest amendment to the structure plan.
- **Part two:** Explanatory Section from the approved structure plan.
- **Addendum 1:** Report for Amendment 2 to the structure plan.

Executive Summary

This is an updated version of the *Lots 1 & 2 Rowley Road Structure Plan* which was approved by Western Australian Planning Commission (WAPC) on 16 June 2016, as a result of a structure plan amendment (Amendment No.1). The structure plan provides guidance for the planning and use of the balance land within the structure plan area.

The structure plan provides for a mix of low and medium density residential land use with public open space. Amendment No. 2 to the approved structure plan will re-code a portion of the structure plan area in the north-east from R40 to R20. This is primarily in consideration of market demand and planning the residual land in the north-east portion of the structure plan. The R20 coding will provide for a handful of larger residential lots of around 700m2 - 800m2. These lifestyle size lots will add to the diversity of housing accommodation in the development and wider community.

The original structure plan area has been partially developed for urban residential use since its original endorsement by WAPC in June 2012. Approximately 60% of the structure plan area has now been subdivided for mostly single dwelling (low-medium density) lots, with the balance area the subject of subdivision conditional approvals.

The following table is an updated summary of the structure plan which now accounts for Amendment No. 2.

Item	Data	Section number referenced within the Structure Plan Report
Gross Structure Plan Area	11.4474 hectares	1.2
Area of each land use proposed		1.2
Zones - Residential	8.25 hectares	
Public Open Space	1.363 hectares (12.5%)	1.3
Estimated Lot Yield	170 lots	1.2
Estimated Number of Dwellings	170 dwellings	1.2
Estimated Residential Density		1.2
• dwellings per gross hectare as *per Directions 2031*	15 dwellings per gross hectare	
• dwellings per site hectare as *per Liveable Neighbourhoods*	20 dwellings per site hectare	
Estimated Population	501 people @ 2.8 people/ household	1.2

Part One - Implementation

Structure Plan Area

This Structure Plan shall apply to the land contained within the inner edge of the line denoting the Structure Plan boundary on the Structure Plan Map.

Operation

The date the Structure Plan comes into effect is the date the Structure Plan is approved by the Western Australian Planning Commission as set out in the Structure Plan - Certification Page.

Staging

Approximately 60% of the structure plan area has now been developed. Future staging will be from east to west as an extension of current services within the development. The residual area in the north-east will likely form part of the initial stages of development. The larger area of public open space in the south western area of the Structure Plan is proposed to be created as part of subdivision of lots in the western portion. The proposed road widening has already been provided as part of the already developed 60% portion of the structure plan area.

Subdivision and Development Requirements

4.1	Land Use & Permissibility	The Structure Plan Map outlines the Zones and Reserves applicable within the Structure Plan Area and these will guide future subdivision and development of the land. Land use permissibility within the Structure Plan Area shall generally be in accordance with the corresponding Zone under the Shire of Serpentine Jarrahdale Town Planning Scheme No. 2 (TPS 2).
4.2	Residential Density	1. Residential densities applicable to the Structure Plan Area shall be those residential densities shown on the Structure Plan Map. 2. The Structure Plan shall provide for a minimum 15 dwellings per site hectare at the subdivision approval stage.
4.3	Local Development Plans	1. Local Development Plans (LDP's) are required to be prepared and implemented pursuant to the provisions of TPS 2 and the Planning & Development (Local Planning Schemes) Regulations 2015, for lots with the following site attributes, but not limited to: i. Lots with direct boundary frontage to an area of Public Open Space; ii. Lots subject to Noise Attenuation provisions; and iii. Lots serviced by a rear laneway (rear-loaded lots).

Additional Requirements

The following investigations and management plans may be required at the subdivision stage, where appropriate:

- Urban Water Management Plan (aligning with the Local Water Management Strategy);
- Public Open Space Management Plan/s;
- Acoustic Report (addressing noise impacts from Rowley Road - north).; and
- Bushfire Management Plan.

Legend

▬ · ▬ Structure Plan Boundary

Reserves

🟩 Public Open Space and Drainage

Zones

▨ Residential R20

▨ Residential R30

▨ Residential R40

Plan Notes

1. Slip lanes may be required for subdivision road access to the satisfaction of the City of Armadale and Shire of Serpentine Jarrahdale.
2. A Noise Impact Assessment consistent with State Planning Policy 5.4 Road and Rail Noise is to be prepare and implemented. Lots may be subject to memorial notifications relating to potential adverse impact from transport noise.
3. The road and intersection design for surrounding roads is shown indicatively and is subject to final engineering design and approval at subdivision stage.

Structure Plan

Lots 1 and 2 Rowley Road, Darling Downs

Date: 20 Apr 2020 Scale: 1:2000@ A3 1:1000 @ A1 File: **19-588 ST-1** Staff: JP GW Checked: JP

0 20 40m

element.

Level 18, 191 St Georges Terrace, Perth Western Australia 6000.
PO Box 7375 Cloisters Square, Perth Western Australia 6850.
T. +61 8 9289 8300 | **E.** hello@elementwa.com.au **elementwa.com.au**

Part Two - Explanatory Section Notes

An amendment (Amendment No. 1) to the Lots 1 & 2 Rowley Road Structure Plan was approved by the Western Australian Planning Commission on 27 June 2016.

Amendment No. 2

Amendment No. 2 re-codes a 4,454m2 portion of the structure plan area in the north-east from R40 to R20. This land is residual and was formerly proposed as a medium density grouped housing site. However given the impacts of transport noise and its location, a reconsideration of the density coding for this area leads to a more effective R20 density being a better planning outcome.

Early pre-lodgement consultations were undertaken and these are summarised in Table 1 in Addendum No. 1 to this structure plan. The Addendum No. 1 report provides the rationale and planning framework to support the structure plan amendment.

As part of the approved structure plan, technical reports and planning rationale were provided with the approved structure plan documentation. Rather than duplicate this information, which remains relevant (notwithstanding the modifications and updates in this structure plan document), the Commission approved Lots 1 & 2 Rowley Road Structure Plan (2016) should be read in conjunction with this structure plan report.

The approved structure plan Part 2 is retained in this **Part 2 – Explanatory Section.**

Addendum No. 1 to this structure plan provides supplementary updates, details and planning justification for Amendment No. 2 to the approved structure plan.

LOTS 1 & 2 ROWLEY ROAD, DARLING DOWNS
STRUCTURE PLAN

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PART TWO (EXPLANATORY SECTION)

1.0 INTRODUCTION

1.1 Lots 1 & 2 Rowley Road Local Structure Plan 2012

As part of the WAPC endorsed *Lots 1& 2 Rowley Road Local Structure Plan 2012*, technical reports and planning rationale was provided within the structure plan documentation. Rather than duplicate this information, which remains relevant (other than the updates in this SP report), the *Lots 1& 2 Rowley Road Local Structure Plan 2012* report (**Appendix 1**) should be read in conjunction with this Part Two (Explanatory Section).

The following sections provide supplementary updates, details and justification for the proposed modifications to the *Lots 1& 2 Rowley Road Local Structure Plan 2012* (herein referred to as the "approved SP 2012").

Where there is any inconsistency between the 2012 Structure Plan and this document, this document prevails.

2.0 LOCAL STRUCTURE PLAN UPDATES

2.1 Summary of modifications to approved SP 2012

Table 1 outlines the proposed variations to the WAPC endorsed *Lots 1& 2 Rowley Road Local Structure Plan 2012.*

Table 1. Proposed modifications to approved SP 2012

Proposed SP amendments	Justification/Rationale
Increase in public open space	The public open space (POS) in the south-west portion of the SP provides a local and district drainage function. In order to provide for adequate water sensitive urban stormwater management, an increase in the size of the POS is required. The increase in area of POS is shown on the SP map. An updated POS schedule is provided which demonstrates that the proposed SP meets the minimum 10% POS provision. The proposed Amended SP now provides for 12.5% POS, as shown in section 2.3 of this report, which is above the 10% provision provided for in the original SP 2012.
Removal of 'Grouped Housing' notation for large lots in NW & NE corner	The Proponent proposes to subdivide these large sites as green title 'Single Dwelling' (rear loaded) laneway lots, which will provide a lot yield equivalent to 'Grouped Housing'. The equivalent lot yield will be achieved through narrow lot product (i.e. typically 7.5m frontage). **Plan 3** demonstrates how these sites can be developed and serviced as single dwelling lots. Table 2 in this report demonstrates the change in housing product type will not impact on ability to achieve target density under Directions 2031.
Modification to road layout	As a result of the increase in size to the POS area, the original road layout in the approved SP 2012 requires modification. Under the proposed modifications to the SP, a road interface is proposed between new R40 areas and the POS area.

2.2 Residential Densities and Yield

As a result of the above proposed variations to the approved SP 2012, the proposed SP ultimately provides for approximately 179 dwellings with a density coding ranging from R20, R30 & R40. The revised dwelling estimate is provided as follows:

Original Estimated Dwelling Yield (approved SP 2012)

WAPC 145280 subdivision application	185 dwellings (includes estimated dwelling yield from grouped housing sites)

Proposed Estimated Dwelling Yield of modified SP

WAPC 145280, 151809 & 462-15 subdivision & survey strata applications	179 dwellings

Table 2 provides development statistics which can be used to measure the performance of the SP (and above subdivision applications) against the key target outcomes of *Directions 2031* and *Liveable Neighbourhoods*.

Table 2 Estimated Development Outcomes for SP

	Site Outcomes	Target Density
Total SP Landholdings Area	11.4474 hectares	-
Area set aside for roads, drainage & POS	3.23 hectares	-
Balance area for residential development	8.21 hectares	-
Estimate ultimate number of dwellings	179 dwellings	-
Estimated number dwellings per *site hectare*[1]	22 dwellings/ha	**Liveable Neighbourhoods** 12 – 20 dwellings per site hectare for standard lot layouts 20 – 30 dwellings per site hectare for lots within proximity to activity centres
SP target density per *gross urban hectare*[2]	16 dwellings/site ha	**Directions 2031** 15 dwellings per gross urban hectare

Notes for Table 2

[1] Liveable Neighbourhoods definition of *site hectare* is the area available for residential development excluding roads, non-residential uses, public open space and drainage areas.

[2] Directions 2031 definition of *gross urban hectare* is the gross area available for urban development

The SP delivers approximately 18 dwellings per *site hectare*, which exceeds the Liveable Neighbourhoods density expectations for the site's locational context. Similarly, the SP delivers approximately 16 dwellings per gross urban hectare, which exceeds the target density of 15 dwellings per gross urban hectare under Directions 2031. Approximately 501 persons (based on average 2.8 persons per dwelling) are expected to live within the SP area.

2.3 Public Open Space Schedule

Table 3 provides an updated POS schedule based on the WAPC approved SP 2012 POS calculations and updated LWMS (see Hyd2o LWMS Addendum dated 15 October 2015 **Appendix 2**), including increase to POS area as provided for in this proposed SP. The increased area in POS will primarily be used for 1:100yr stormwater drainage storage infrastructure and therefore the added POS area to the SP provides more useable POS for active and passive recreation as shown in **Plan 2**.

2.4 SPP 3.7 'Planning in Bushfire Prone Areas'

The subject site is affected by Department of Fire and Emergency Services Bushfire Prone Mapping as per below extract from DFES database. Notwithstanding the DFES mapping, neighbouring areas to the west and north have been cleared as part of urban subdivision and the threat of bushfire from vegetation in these areas has been removed.

The DFES mapping has since not been updated to reflect vegetation clearing. The surrounding semi-rural land uses to the south and west have generally been parkland cleared for rural pursuit but still pose some degree of bushfire risk.

Accordingly Bushfire Attack Level (BAL) Contour Plan Report has been prepared demonstrating that the proposed lots in the Structure Plan can be adequately protected and developed in accordance with SPP 3.7. The BAL Assessment is contained in **Appendix 4**.

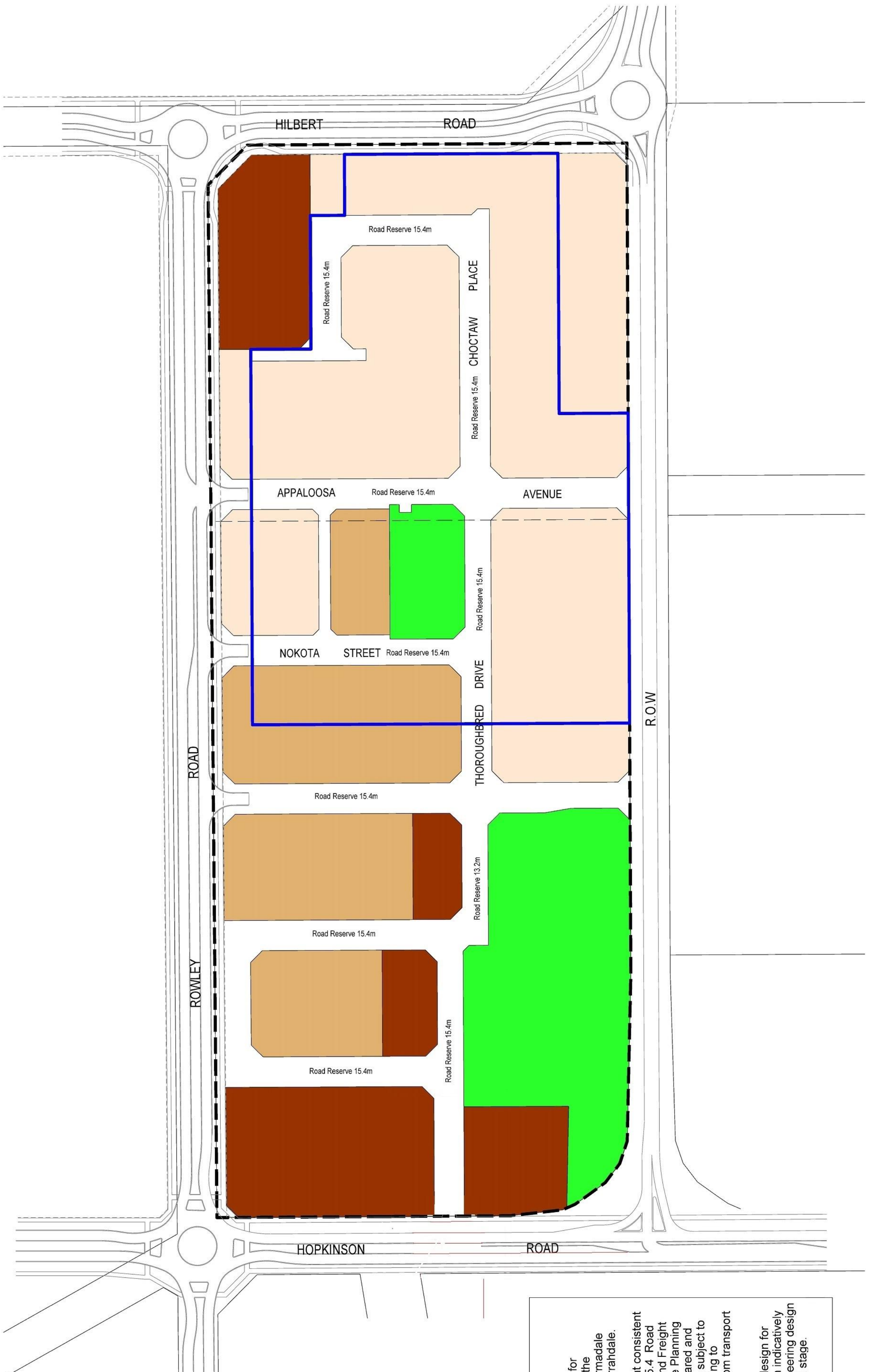
Table 3. Updated POS Schedule for Lots 1 & 2 Rowley Road Structure Plan

Calculation of Required POS Provision		
Original Lots 1 & 2 (now subdivided) **Total Site Area** **(ha)**	11.447	11.447
Deductions		
Rowley Road (requirements for regional road widening)	0.371	
Dedicated Drainage		
Birrega Living Stream (district main drain)	0.072	
DD1 detention basin (1:1yr)	0.069	
DD2 detention basin (1:1yr)	0.051	
Total Deductions		0.563
Gross Subdivisible area (total area minus deductions)		10.884
Required POS (10%)		**1.088**
Breakdown of POS Provided		
May comprise:		
- minimum 80 per cent unrestricted POS	0.870	
- Maximum 20 per cent restricted use POS	0.237	1.107
Public Open Space Contribution		
Unrestricted POS (Non-Drainage Areas > 5yr ARI)		
Local Parks		
Local Park (LP1) central	0.176	
Local Park (LP2) south west	1.170	
Total Unrestricted POS		**1.346**
Restricted POS		
1:5yr ARI drainage		
DS1 central	0.01	
DS2 south west	0.007	
Total Restricted POS		**0.017**
Total Public Open Space provision provided		**1.363**[1]
POS Provision as Percentage of Gross Subdivisible Area (refer to Note 3)		(12.5%)

Table Notes:

1. Final POS calculations will be subject to detailed survey and approved Urban Water Management Plan. A minimum of 10% POS land contribution to be provided at Survey Deposited Plan final approval stage.

PLANS



LEGEND

ZONES

🟫	Residential - R40
🟫	Residential - R30
▢	Residential - R20

RESERVES

🟩	Public Open Space and Drainage
▭	Area of Structure Plan constructed (Stages 1 & 2) with areas outside subject to future subdivision
⌐	Structure Plan Boundary

PLAN NOTES

1. Slip lanes may be required for subdivision road access to the satisfaction of the City of Armadale and Shire of Serpentine Jarrahdale.
2. A Noise Impact Assessment consistent with State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning (as amended) is to be prepared and implemented. Lots may be subject to memorial notifications relating to potential adverse impact from transport noise.
3. The road and intersection design for surrounding roads is shown indicatively and is subject to final engineering design and approval at subdivision stage.

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STRUCTURE PLAN
LOTS 1 & 2 ROWLEY ROAD
DARLING DOWNS

DATE DRAWN: 11/08/2016
DRAWN BY: CdeL
CHECKED BY: JP
FILE: 150819 Structure Plan 20200-rev 2.dgn
V DATUM: AHD
H DATUM: MGA94 (50)

Plan No. : 20200-8
Revision : REV. 3
Scale : 1:2000@A3

0 20 40 60

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Member Practice

Suite 4 First Floor 40 Hasler Road Osborne Park WA 6017 www.whelans.com.au

POS to be reserved for Public Open Space and Drainage purposes in accordance with the approved Local Water Management Strategy

Plan No. : 20200-8
Revision : REV.0
Scale :1:2000@A3

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LEGEND

Zones		Reserves		Other	
🟫	Residential - R40	🟩	Public Open Space	⌐ ¬	Structure Plan Boundary
🟫	Residential - R30			⇦	Birrega Main Drain culvert crossings
▭	Residential - R20			▭	Constructed stages

PUBLIC OPEN SPACE NETWORK

PLAN 2

DATE DRAWN: 20/08/2015
DRAWN BY: CdeL
CHECKED BY: JP

FILE: 150819 Structure Plan.dgn
V DATUM: AHD
H DATUM: MGA94 (50)

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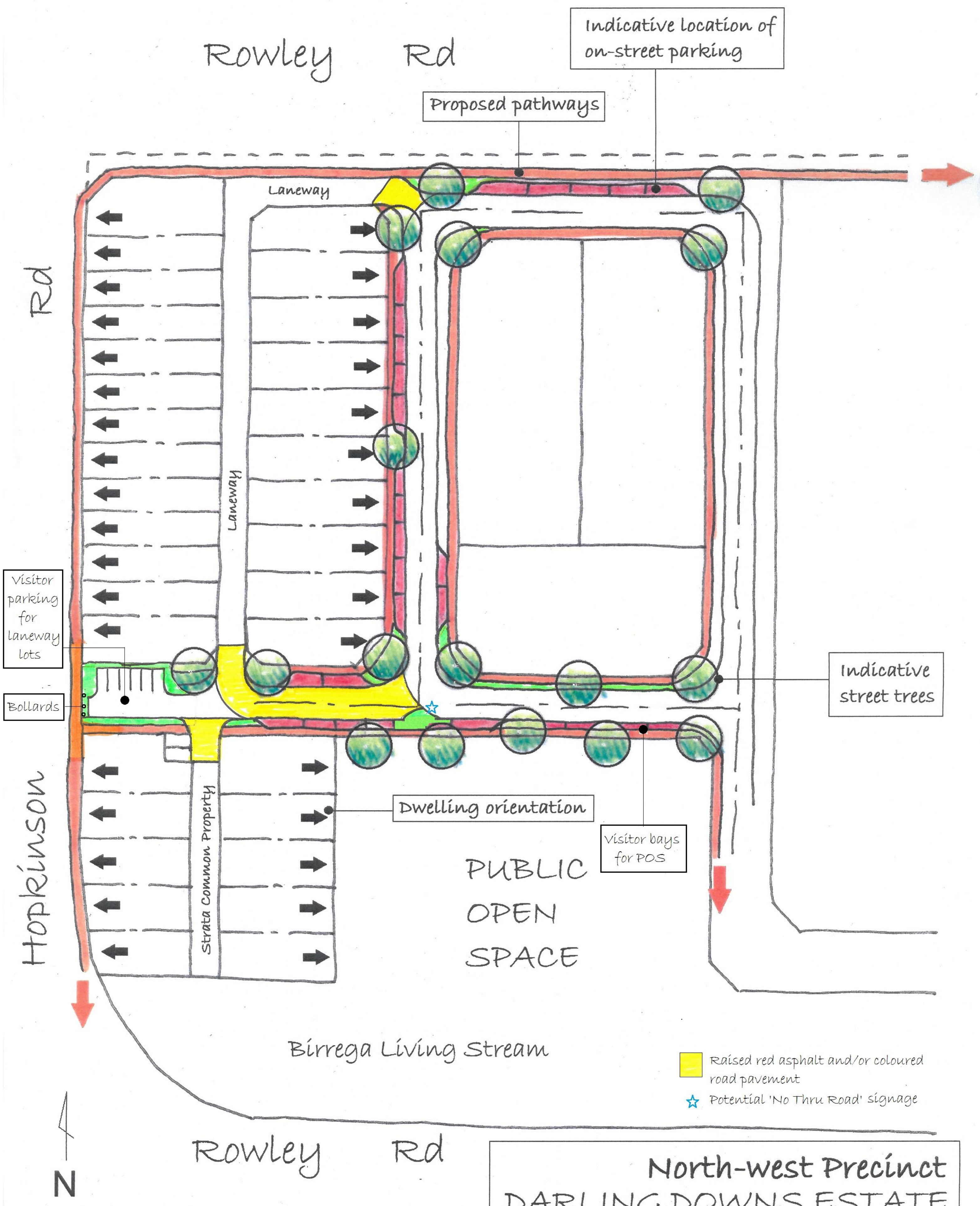

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Scale: Not to scale

North-west Precinct
DARLING DOWNS ESTATE

(WAPC Subdivision ref: 151809)

PLAN 3

APPENDIX 1

LOTS 1 & 2 ROWLEY ROAD LOCAL STRUCTURE PLAN 2012

GREG ROWE & associates
FOCUSED ON ACHIEVEMENT

LOCAL STRUCTURE PLAN
LOTS 1 & 2 ROWLEY ROAD, DARLING DOWNS

GRA REF 4678 6 JUNE 2012

SJS TRIM - IN12/8716

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FIGURES

APPENDICES

1.0 Operation of Local Structure Plan

This Structure Plan shall apply to Lots 1 and 2 Rowley Road, Darling Downs, depicted within the subject site boundaries under Figure 1.

This Structure Plan begins operation on the date it is adopted by the local government pursuant to Clause 5.18.3.5 of the Scheme.

Refer to Figure 1 – Local Structure Plan.

1.1 Interpretation

The words and expressions used in this Structure Plan shall have the same respective meanings given to them in the Shire of Serpentine Jarrahdale Town Planning Scheme No.2.

1.2 Relationship with the Scheme

This Structure Plan is to operate in accordance with the provisions of Clause 5.18.6 of the Scheme.

The Structure Plan identifies reserves and zones, including residential densities. Use and development within the Structure Plan area is to be in accordance with the provisions of the Scheme as if the reserves and zones as depicted in the Local Structure Plan Map (Figure 1) were actual reserves and zones. The Structure Plan is binding and enforceable in the same way as corresponding provisions incorporated in the Scheme.

If a provision of the Structure Plan imposes a classification on the land included in it is inconsistent with a provision of the Scheme, then the provision of the Scheme prevails to the extent of any inconsistency.

Upon completion of development within the Local Structure Plan area, the Shire of Serpentine- Jarrahdale will initiate an amendment to the Scheme to reflect the final zonings.

1.3 Operation Date

In accordance with sub-clause 5.18.6 of the Scheme, this Structure Plan shall come into operation when it is adopted by the Council pursuant to sub-clause 5.18.3.15 of the Scheme.

1.4 Local Authority Scheme Reserves

The provisions for these reserves shall be in accordance with those contained in the Scheme for 'Local Authority Reserves'.

1.5 Residential Zone

The purpose and intent of the Residential Zone is to maximise the use of land within immediate proximity to urban development and infrastructure as planned within the Wungong Urban Water Master Plan. Residential Development is to be integrated with the surrounding urban development planned to the north, east and west whilst providing a soft landscaped interface with rural development to the south.

1.6 Land Use Permissibility

Land use permissibility within the Residential Zone shall be in accordance with the corresponding zone under the Scheme.

1.7 Development Requirements

The standards and development requirements applicable to the zones and R-Codings under the Scheme apply to the areas having corresponding designations under the Structure Plan Map.

The planning approval procedures including the procedures for the approval of uses and developments under the Scheme are to apply as if the land were correspondingly zoned or reserved under the Scheme.

1.8 Structure Plan Map

The Structure Plan Map outlines the planned pattern of development for the Structure Plan area. All development should be carried out in accordance with the principles outlined on the Structure Plan Map.

The road layout depicted on the Structure Plan Map is indicative only and is subject to detailed planning at the time of subdivision or development.

The Structure Plan is depicted in Figure 1.

1.9 Detailed Area Plans

In accordance with Clause 5.18.5, Detailed Area Plans (DAPs) will be required to be prepared, prior to the clearance of subdivision, for laneway lots, lots with an area of less than 350m^2, lots in the immediate vicinity of Hopkinson and Rowley Roads, grouped dwelling lots and other lots with special circumstances. Lots identified as having a potential noise impact from traffic will also require DAPs.

The DAPs may include the following details:

- » Building envelopes;
- » Private open space;
- » Services;
- » Vehicular access, parking, loading and unloading areas, storage yards, and rubbish collection closures;
- » The location orientation and design of buildings and the space between buildings;
- » Lighting and fencing;

- For lots in the immediate vicinity of Hopkinson and Rowley Roads, development will be determined by the noise assessment to be undertaken or by the achievement of compliance with the Environmental Protection (Noise) Regulations 1997;
- Landscaping finished levels and drainage; and
- Special development controls and guidelines.

The DAP shall become operative on the day that it is endorsed by an authorised officer of the Shire.

Once approved, residential development is to be in accordance with the approved Detailed Area Plans (if applicable), the Residential Design Codes, the Scheme and any relevant Planning Policy.

1.10 Implementation Requirements

The following additional documentation will be provided to support subdivision at a later stage:

- Noise Impact Assessment;
- Traffic Impact Statement;
- Fire Management Plan;
- Landscape Master Plan.

FIGURE 1 LOCAL STRUCTURE PLAN

2.0 Introduction

Greg Rowe and Associates acts on behalf of Deneva Pty Ltd, the landowner of Lots 1 and 2 Rowley Road, Darling Downs ("subject site").

The purpose of the Local Structure Plan ("LSP") is to refine the provisions under the district framework and ensure a comprehensive approach to planning and development is undertaken with input from the local community, landowners, government agencies and other key stakeholders.

The LSP is a statutory planning document that will guide future land use and development within this site and provide a framework for more detailed planning at subdivision.

Under the provisions of the Shire of Serpentine-Jarrahdale Town Planning Scheme No. 2 ("TPS 2"), it is understood a LSP is required for land zoned "Urban Development" which acts as a precursor to the subdivision and future development of land under this zone.

This report includes a description of the following matters:

- Location of the subject site;
- Description of the existing and surrounding land uses, physical features and existing infrastructure of the subject site;
- Opportunities and constraints of the site; and
- Discussion of the design philosophy supporting the LSP.

3.0 Description of Site

3.1 Location and Cadastral Information

The subject site is located in the municipality of the Shire of Serpentine- Jarrahdale, approximately 27 kilometres south east of the Perth Central Area.

Refer Figure 2 – Regional Location.

The subject site is situated in the locality of Darling Downs and is bound by Rowley Road to the South, Hopkinson Road to the west and Hilbert Road to east. The subject site adjoins the boundary of the City of Armadale and abuts the boundary of the Wungong Urban Water ("WUW") Master Plan Area, under the jurisdiction of the Armadale Redevelopment Authority.

The subject site is positioned approximately 1km east of Tonkin Highway's intersection with Rowley Road.

Refer Figure 3 - Local Location.

The subject site comprises two separate land parcels, being:

» Lot 1 on Certificate of Title Volume 1449 Folio 531; and

» Lot 2 on Certificate of Title Volume 1449 Folio 532.

The subject site has a total land area of 11.4474 hectares, with frontages of 5,120 metres to Rowley Road (south) and 1,960 metres to both Hopkinson Road in the west and Hilbert Road to the east.

Refer Figure 4 – Site Plan / Aerial View and Appendix 1 – Certificates of Title.

FIGURE 2 REGIONAL LOCATION

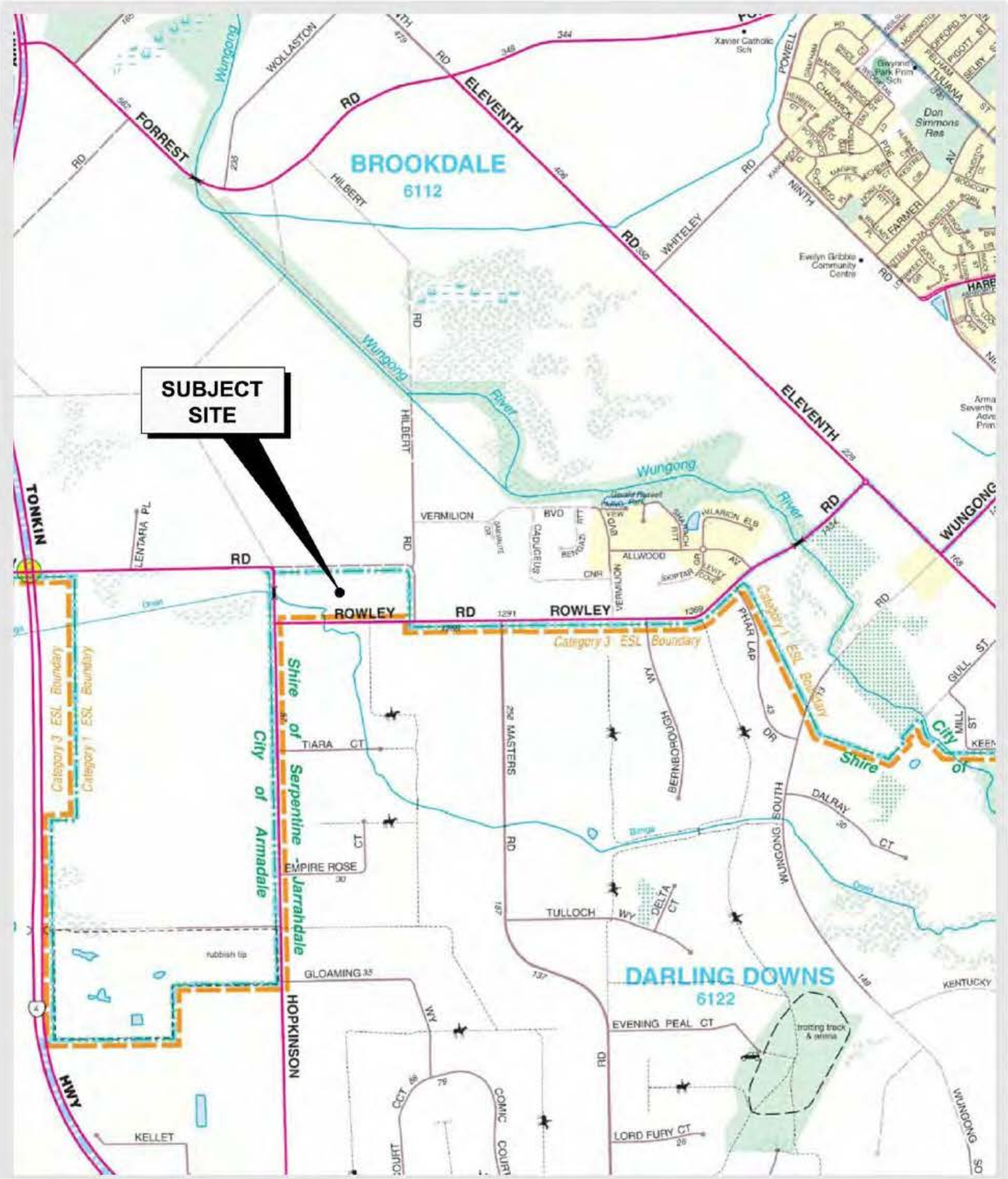

FIGURE 3 LOCAL LOCATION

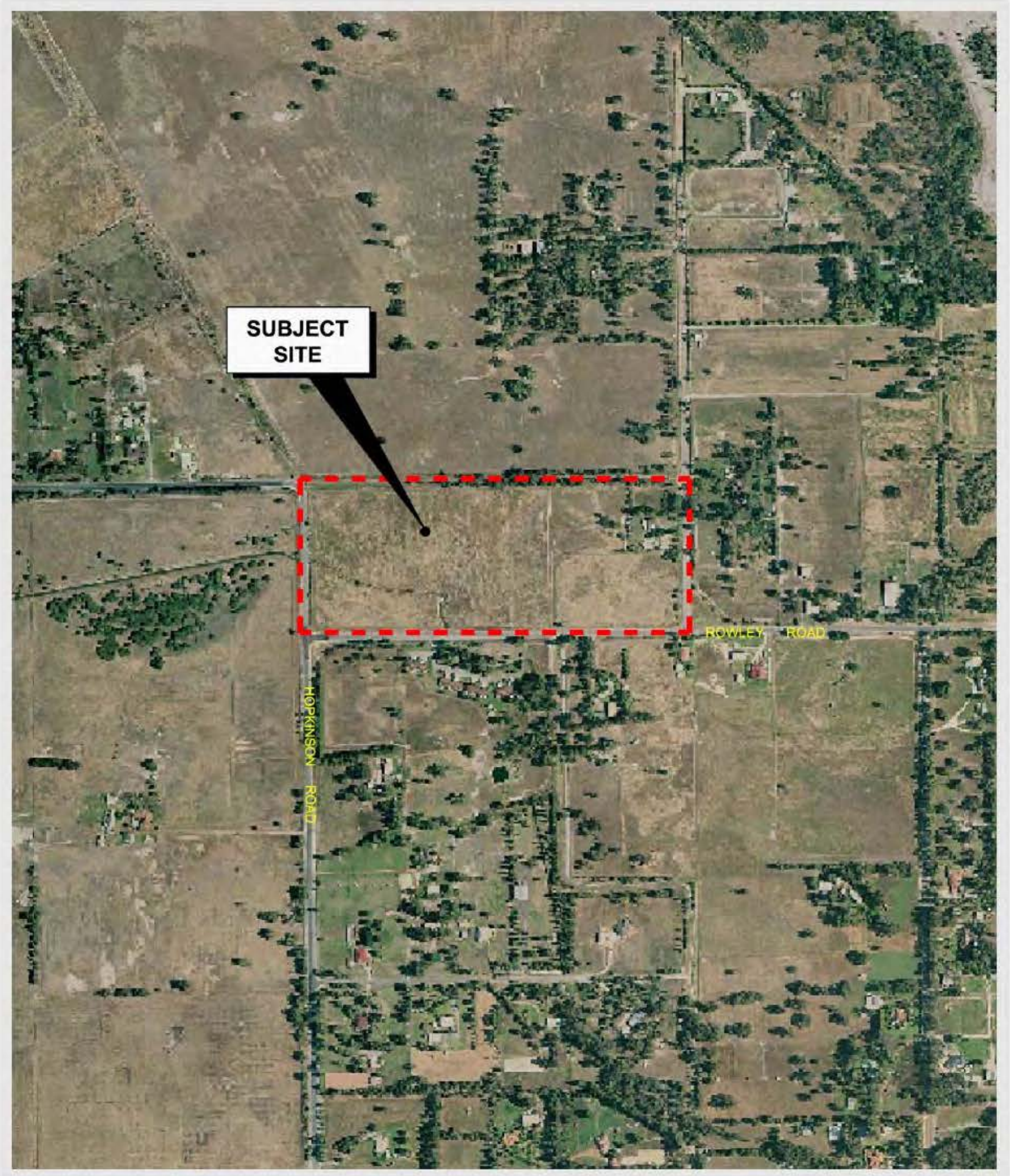

FIGURE 4 SITE PLAN / AERIAL VIEW

3.2 Existing and Surrounding Land Uses

The subject site is currently utilised for rural purposes. Lot 1 has various improvements including a single residential dwelling and several patio structures, whilst Lot 2 is vacant.

A regional drain (Birrega Main Drain) traverses the south-west corner of the subject site. This drain connects with the adjoining lots both to the south and to the west.

The subject site is surrounded by "Urban" zoned land to the north, east and west, however, much of this land has not been developed at this stage. The land to the south of the subject site comprises "Rural" zoned land, and is occupied by aged persons housing and rural lifestyle lots.

The WUW Master Plan proposes a "Neighbourhood Centre" be located at the intersection of Rowley Road and Hopkinson Street, directly abutting the subject site's north-west extremities.

Refer Appendix 2 – Wungong Urban Water Master Plan.

3.2.1 Regional and Neighbourhood Structure

The current neighbourhood structure of the locality has been based predominantly on rural-residential principles with an established Rural-Residential estate being located directly to the south of the subject site. A number of "Special Rural" zones also exist within that estate under the provisions of TPS 2.

The proposed 'Village Centre' adjacent to the north-west boundary of the subject site will ultimately form an integral part of the proposed community with respect to the provision of services and community facilities, variety of land uses and population density. This LSP proposes to locate compatible and complimentary residential land uses in close proximity to the proposed 'Village Centre'.

This LSP is therefore proposed to fully integrate with the surrounding neighbourhood, taking advantage of the proposed structure of the future community under the WUW Master Plan.

3.2.2 Activity Centres

The subject site is currently serviced by the commercial centres within the Armadale and Byford localities. There are no existing commercial centres within the locality of Darling Downs.

The area north west of the subject site is earmarked for the location of a Neighbourhood Activity Centre with the potential to accommodate up to 4,500m^2 retail floorspace. The proximity to this centre provides the opportunity to maximise development within a walkable catchment to this centre through a more intensive form of residential development.

Any future development within the immediate vicinity of the Neighbourhood Centre will be required to comply with the Noise Regulations. Lots in the vicinity of the Neighbourhood Centre will also be subject to detailed area plans to ensure uniformity with surrounding development.

3.2.3 School Sites

There are currently no school sites within the Darling Downs locality, with the closest sites located to the north east in Armadale.

Armadale High School is located approximately 3.7km to the north east of the subject site. There are also several Primary Schools within the Armadale locality with the nearest schools being Armadale Adventist Primary School and Dale Christian Primary School located approximately 2.5km north east of the subject site.

The area immediately north of the site is subject to the Wungong Urban Water Master Plan - Precinct K Local Structure Plan, which includes a planned High School site to the north west of the Local Centre as well as a Primary School site to the north of the subject site along Hilbert Road. There are no proposed dates for the opening of these latter two Primary Schools at this stage.

3.3 Environmental Opportunities and Constraints

The WUW Master Plan contains a comprehensive summary of the relevant environmental issues applicable to the subject site. The following is a summary of the environmental issues relevant to the subject site, as outlined within the WUW Master Plan.

3.3.1 Landform / Topography

The landform within the locality is predominantly low lying, with little to no variations in the topography. The subject site is located on the eastern portion of the Swan Coastal Plain, typically undulating with higher elevations being associated with the Bassendean and Guildford sands.

The WUW Master Plan identifies the locality as being characterised by a number of low-lying swamp/lake features that provide visual relief to the predominantly flat character. It further identifies there are limited natural features that could be utilised to improve the future residential amenity.

Consistent with the above, the subject site is predominantly flat with a slight upward variation in the topography adjacent to the central eastern boundary. Topographic contours for the subject site indicate that the majority of land ranges from approximately 26m AHD along the western boundary to 27m AHD.

3.3.2 Hydrology

The subject site is affected by the Birrega Main Drain which joins the Serpentine River and ultimately discharge to the Peel Harvey Estuary. The Birrega Main Drain is located within the Mundijong Rural Drainage District and is a rural drain under the management of the Water Corporation.

The Birrega Main Drain flows beneath Rowley Road in a northerly direction and changes course midway though the study area, flowing west under Hopkinson Road and continuing west to Tonkin Highway. The WUW Master Plan proposes the realignment of the Birrega Main Drain to the west of the site. The realignment to the west of the site is designed to assist in achieving the planning outcomes and in particular environmental objectives through linking the drain to areas of significant vegetation protection, while also improving the hydraulic performance of the Drain.

3.3.3 Vegetation

A Flora and Vegetation Survey of the subject site was prepared by ENV Australia (refer to Appendix 4). The findings of the survey are summarised as follows:

- The condition of vegetation across the site is 'Totally Degraded' with little native vegetation remaining, and the presence of weedy pasture species;
- The subject site contains 34 flora taxa, of which 5 are native;
- No Declared Rare Flora or Priority Flora taxa appear to occur on site; and
- No Threatened Ecological Communities occur at the site, which has been totally cleared.

3.3.4 Soils

The WUW Master Plan Environmental Assessment identifies the subject site as being located within the Beermullah soil system, characterised by the Waters and Rivers Commission as being a poorly drained plain of sand and loam over clay, in a flat plain, waterlogged in winter, often saline. The subject site is characterised by sandy clay/clayey sand soils as identified under the Geological Survey of WA (1986).

A geotechnical investigation of the subject site was undertaken in 2008 to assess the sub-surface conditions and determine the suitability of the land to support urban development. A copy of the geotechnical investigation report is available upon request.

3.3.5 Acid Sulfate Soils

The subject site is located in an area identified under the Department of Environment and Conservation ("DEC") mapping as 'moderate to low risk of Acid Sulphate Soils occurring within 3m of natural soil surface'. The proposal will have limited potential for disturbance of acid sulphate soils as excavation will be limited to the realignment of the Birrega Main Drain and clean fill will be used where required.

3.3.6 Conservation and Heritage

A search of the Department of Indigenous Affairs Database indicates that the site does not contain a listed "Aboriginal Heritage Site".

3.4 Accessibility Assessment

The site is currently well serviced by the local road network being Rowley Road (north and south), Hopkinson Road and Hilbert Road.

3.4.1 Rowley Road

Rowley Road north is currently unconstructed and Rowley Road south is currently occupied as the direct east-west link for major traffic. Rowley Road is controlled by Main Roads and comprises a 20m road reserve. Main Roads have advised that the Rowley Road north road reserve is to be increased to a 30m width to facilitate upgrades, as such the subject site will allow for 5m road widening along the northern boundary.

3.4.2 Public Transport

The subject site is currently in the vicinity of two Transperth bus routes. The nearest bus stops is located approximately 370m to the east near the intersection of Masters Road and Rowley Road and a second bus stop is located approximately 580m to the south near the intersection of Hopkinson Road and Tiara Court. The service currently provided to these stops is very limited with only two bus services per day. The subject site's location adjacent to future urban land to the north, east and west will support upgrades to the public transport network.

3.5 Opportunities and Constraints

From the above assessment of the site a number of site constraints and opportunities were identified in the design process, these include:

Constraints

- The treatment of the Birrega Main Drain;
- The adjacent rural residential community and any perceived impact which residential development may have upon the existing lifestyle and amenity of the locality;
- The configuration of the LSP area being a small urban cell separated by the location of four major roads; and
- The proposed treatments to Rowley Road.

Opportunities

- Improved management and performance of Birrega Main Drain;
- Proximity to planned urban development to the north east and west including a planned Neighbourhood Activity Centre, High School site and Primary School site;
- Provide a more intensive and efficient use of urban land;
- Improvements to existing road network including upgrades to Rowley Road north shifting major traffic movements away from the rural residential land to the south of the site; and
- Enhanced vegetation throughout the site within road reserves and POS.

4.0 Town Planning Framework

4.1 Regional Planning

4.1.1 Metropolitan Region Scheme zoning

The subject site is currently zoned "Urban" under the provisions of the Metropolitan Region Scheme ("MRS").

Refer to Figure 5 – MRS Zoning

4.1.2 Wungong Urban Water Master Plan

The subject site is immediately adjoining the Wungong Urban Water ("WUW") Master Plan Area to the north and west. This is an area of land of approximately 1,500 ha, which is part of the Armadale Redevelopment Authority's ("ARA") "Redevelopment Area" as defined under the *Armadale Redevelopment Act 2001*.

The ARA is responsible for the preparation and implementation of a Master Plan that provides a planning framework for the redevelopment of the project area comprising predominantly of an urban form, and also includes an environmental and hydrological context.

The WUW Master Plan provides a guide to the future development of the study area and management of key environmental issues. It has identified many of the study area's opportunities and constraints such as the high water table, nutrient, drainage and water resource management, conservation areas, multiple ownership and community expectation.

The WUW Master Plan forms a critical component of the rationale and design philosophy which has informed the proposed LSP for the subject site. The Wungong Urban Water area is also subject to a number of Policies and Place Codes implemented by the ARA that are used to guide the development of structure plans within the project area.

The WUW Master Plan has been split into a number of Cells, immediately surrounding the subject site to the north and west is the Cell K Local Structure Plan, and the Cell 1B Local Structure Plan is located to the east (refer to Appendix 3). The Cell 1B Local Structure Plan has been adopted by the ARA. These Local Structure Plans are generally consistent with the land use designation under the WUW Master Plan.

The subject site is immediately adjoining an area that has been identified as a future "Neighbourhood Activity Centre" north west of the site, a future "Living Stream" to the west and "Urban" and "Suburban" land to the north, east and west.

The WUW Master Plan reconfigures several Water Corporation Drains into "Living Streams". The Birrega Main Drain traverses the subject site. In accordance with the WUW Master Plan the Birrega Main Drain will be realigned to the west of the site and will be developed as a "Living Stream".

The proposed realignment of the Birrega Main Drain to the west of the site will result in the portion of the drain currently located within the subject site being relocated along Rowley Road (south) and linking into the designated realigned drain to the west. A Local Water Management Strategy ("LWMS") has been prepared for the subject site by JDA Consulting Hydrologists. This LWMS (a copy of which is provided in Appendix 5) details investigations of the hydraulic implications of staged construction of the realignment of the Birrega Main Drain and found both filling of the subject site for development and a staged realignment of the drain could occur without adversely affecting flood levels either upstream or downstream. The investigations found future realignment of the Birrega Main Drain downstream of the subject site would provide opportunities for an overall improved hydraulic performance of the Birrega Main Drain system.

ARA Policy states that Neighbourhood and Local Centres are intended to provide for convenience retailing, local offices, a public transport stop and a post box and civic/community services and facilities in a main streets style centre and provide a focal point for the local community. Neighbourhood Activity Centres have been distributed throughout the WUW area to provide a 400-500m walkable distance for most residents. Areas immediately adjoining Neighbourhood Centres generally within a 400-500m catchment have been designated as "Urban" areas comprising residential lots ranging between 160m² to 350m² in size. "Suburban" development zones have been provided with lot sizes ranging between 200m² to 575m².

4.2 Local Planning

4.2.1 Shire of Serpentine-Jarrahdale Town Planning Scheme No. 2

The subject site has recently been rezoned "Urban Development" under the provisions of the Shire of Serpentine Jarrahdale Town Planning Scheme No.2 ("TPS 2"). TPS 2 states the following:

> *"The purpose of the Urban Development Zone is to provide for the orderly planning of large areas of land in a locally integrated manner within a regional context, whilst retaining flexibility to review planning with changing circumstances."*

The subject site is located within Development Area No.4 of TPS 2 and as such is subject to the requirements listed under Appendix 15 of TPS 2. TPS 2 requires the preparation of a LSP within a Development Area prior to subdivision. This report has been prepared in accordance with these requirements.

Refer to Figure 7 – TPS 2 Zoning.

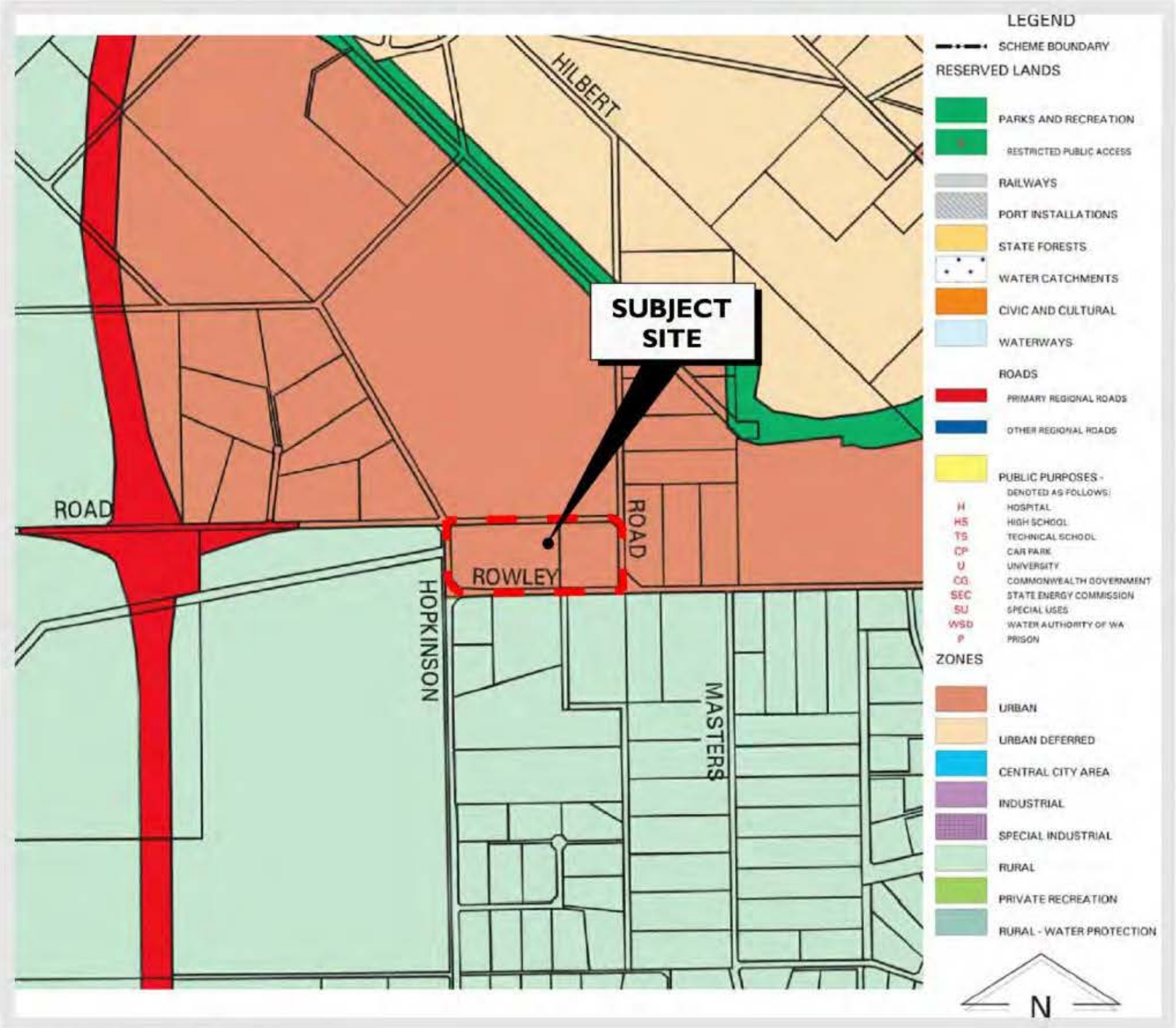

FIGURE 5 MRS ZONING

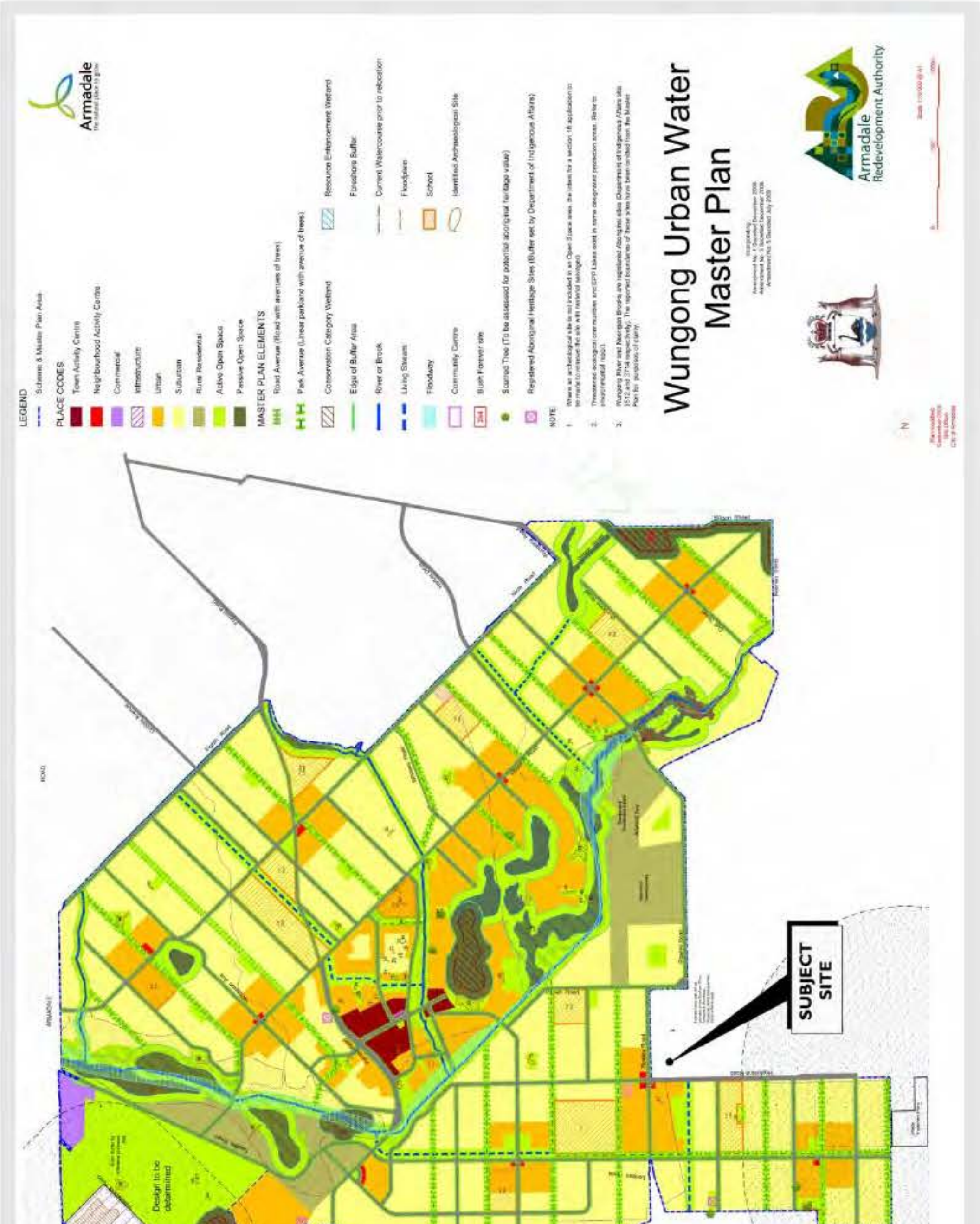

FIGURE 6 WUNGONG URBAN WATER MASTER PLAN

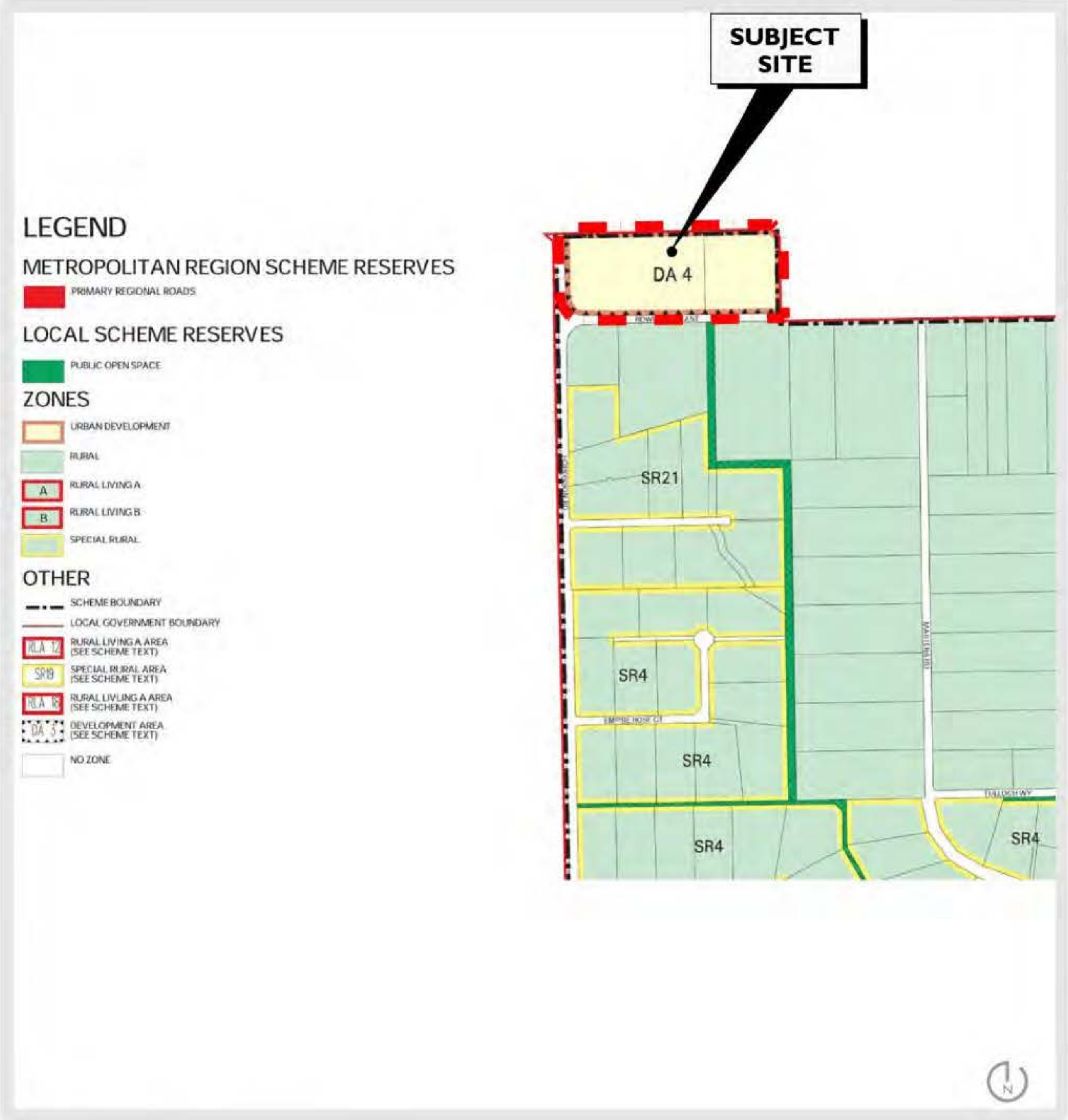

FIGURE 7 TPS 2 ZONING

5.0 Local Structure Plan

This LSP represents a logical extension of urban development to the WUW Master Plan, located immediately to the north, east and west of the subject site.

The following section has been prepared in support of the LSP and addresses the relevant elements of Liveable Neighbourhoods.

The LSP is depicted in Appendix 6.

5.1 Design Objectives

Given the natural and man-made site characteristics the following objectives were identified through the design process:

- To provide a variety of lot sizes that can accommodate a variety of housing product;
- To provide a high quality walkable urban environment;
- To provide a water sensitive design that is responsive to the existing site conditions;
- To provide high quality POS for both passive and active recreation purposes; and
- To improve the amenity of the existing community.

5.2 Design Response to Site and Context Analysis

Given the proximity to future urban development planned under the WUW Master Plan, it is considered appropriate to integrate the proposed development into the surrounding environment. As such, the proposed LSP includes a transition of residential development including higher densities within close proximity to the planned Activity Centre to the north west of the subject site.

The subject site is reasonably unconstrained in terms of existing vegetation and building structures. Subdivision of the subject site will result with the enhancement of vegetation with approximately 11,000m^2 of POS and landscaping throughout road reserves.

The LSP also includes the realignment of the Birrega Main Drain to connect with the "Living Stream" planned to the west of Rowley Road south and improve the maintenance and performance of the Drain. A 30m linear POS reserve is also proposed to the south west of the site to provide the opportunity for better water management. The LWMS prepared by JDA Consulting Hydrologists (refer Appendix 5) investigates the realignment of the Birrega Main Drain that is required to accommodate the future downstream realignment of the Birrega Main Drain detailed in the approved WUW Master Plan. It is understood that the realignment of the Birrega Main Drain was proposed in the WUW Master Plan Area to assist in achieving planning outcomes and in particular environmental objectives through linking the Birrega Main Drain to areas of significant vegetation protection, while also improving the existing hydraulic performance of the drain.

The potential impact on adjoining rural residential development to the south is considered an important aspect to informing the LSP design. It is important to provide a sustainable urban form that will make the most efficient use of the site in accordance with the intended purpose of the "Urban Development" zone whilst providing a suitable interface with development to the south. Medium densities have been provided in order to take advantage of the proximity to urban infrastructure that will be provided immediately adjoining the site. As such, the LSP has provided wider urban lots facing the south and fronting onto a landscaped swale.

The development of the subject site will also facilitate the construction of Rowley Road north shifting major traffic movements away from the rural residential development to the south.

5.2.1 Land Use Description

The LSP area predominantly consists of residential development, providing a variety of low and medium density housing opportunities. The LSP also includes a land area contribution of 10% towards POS.

Residential activity within the subject site comprises predominately medium density single residential lots, however provision has been made for a number of larger grouped housing sites which may be developed for higher density development.

The Birrega Main Drain is proposed to be landscaped and provide a pedestrian connection to the "Living Stream" to the west of Rowley Road south. This will be facilitated by a proposed realignment to the Birrega Main Drain (subject to Water Corporation negotiations and approval). The new alignment of this drain will also contribute to providing an interface to the rural development to the south through the provision of a linear POS reserve.

5.2.2 Existing Vegetation

A Flora and Vegetation Survey of the subject site was prepared by ENV Australia (refer to Appendix 4). The subject site is currently "Totally Degraded" of vegetation with small pockets of trees remaining to the east. The potential to maintain these trees will be affected by the earthworks implications. However, new trees throughout the development will be included as part of a Landscape Master Plan to be prepared during the subdivision stage.

5.2.3 Minimise Effects on Local and Nearby Amenity

Several issues were raised during the advertising process of the Scheme Amendment in relation to the interface treatments, densities and traffic.

The development allows for planned upgrades to Rowley Road and will ultimately result with a shift in the majority of traffic movements being experienced within the northern alignment of Rowley Road, away from the rural residential development to the south.

The impact of urban development will be softened by the provision of a landscaped swale running through the southwest boundary of the subject site.

Further east from the drainage swale low density (R20) lots are proposed. Given the ARA do not support estate walls and fencing, it is expected these residential lots will be fronting the rural lots rather than back on to them. This approach is consistent with urban development intended to the south west of the site. Residential lots will be integrated through suitable landscaping.

5.3 Movement Network

5.3.1 Description of Road Network

The subject site is primarily serviced by Rowley Road south, Hopkinson Road to the west, Hilbert Road to the east and Rowley Road north. It should be noted that Rowley Road north, although a gazetted road, has not yet been constructed. The proposed LSP allows for road widening to accommodate this road.

The internal road network will comprise of predominantly Access Streets comprising road reserve widths of 13.2 m and 15.4m which allows suitable space for a network of dual use paths.

Road widening and truncations have been applied to Rowley Road north and the intersections along Hilbert Road in consultation with Main Roads WA. It is our understanding that Main Roads will require the widening of the Rowley and Hilbert Roads reserves to a total of 30m, with 5m extra on each side. A roundabout is planned towards the south east corner of the subject site and an increased truncation has been applied to the north east of the subject site in accordance with Main Roads' requirements.

In addition, a 6m laneway has been provided for the R30 lots fronting the POS, to allow for direct frontage to the POS.

The realignment of the Birrega Main Drain will result with the provision of a drainage swale along the southwest of the subject site. The use of laneways will avoid the interruption of these swales.

Appropriate road reserve widths within the LSP area have been provided which will allow for appropriate facilities to be included at detailed road design stage.

5.3.2 Connectivity

The local road network has been designed with a high level of connectivity to facilitate walking and cycling and enable relatively direct local vehicle trips in between neighbourhoods and to the Neighbourhood Activity Centre. The connectivity of the road network as well as the linkages provided through POS will contribute to the high level of accessibility for pedestrians in the cell.

The road network has been designed to provide a strong connection to the Neighbourhood Centre. Pedestrian links to the Centre will be provided through a network of dual use paths.

5.4 Lot Layout

5.4.1 Density Targets

The LSP includes a strong focus toward the Neighbourhood Centre to the north west of the subject site. The allocated densities provide a variety of lot sizes including a mixture of R20, R30, and R40 increasing towards the Neighbourhood Centre. These densities are similar to those identified under the WUW Place Codes for the area to the north.

The LSP comprises the following potential lot and dwelling yields:

R Code	Likely Number of Lots	Likely Number of Dwellings	Total Site Area (m^2)
R40	11	72	17,245m^2
R30	58	58	19,878m^2
R20	70	70	37,883m^2
Total	**139**	**200**	**75,006m^2**

Liveable Neighbourhoods provides the following density targets:

- 12 to 20 dwellings per site hectare is required for standard lot layouts, distributed to achieve any required urban density of dwelling yield;
- 20 to 30 dwellings per site hectare in 400m of Neighbourhood Centres; and
- 30 to 40 dwellings per site hectare for areas in 400m of Town Centres.

Across the LSP area an average residential density of 26 dwellings per site hectare is achieved in accordance with the above requirement.

5.4.2 Lot Size and Variety

To ensure the efficient use of urban land, specifically in proximity to the proposed activity centre to the north west of the subject site, both higher densities and a range of lot sizes are proposed for the area to facilitate a variety in housing product.

As previously discussed, the mixture of densities will include a gradual increase toward the proposed Neighbourhood Centre to the north east. The LSP includes a mixture of grouped dwelling and single dwelling sites including density codings of R20, R30 and R40.

A mixture of R20 density lots are also proposed within the LSP and are predominantly located to the east of the cell and along the southern boundary of the site. Residential lot sizes at R20 densities are considered sustainable in an "Urban" zone and will contribute to the efficiency of the proposed Activity Centre.

Development reflecting medium densities of R30 and R40 is proposed around POS sites in accordance with Liveable Neighbourhoods. Some lots have been provided with direct frontage to POS to increase surveillance and vehicle access through the rear laneways. It is expected that development of these lots will be subject to the provisions of Detailed Area Plans which would include provisions in relation to dwelling frontage, garage location, etc.

Three R40 grouped dwelling sites are proposed and would allow for a total of approximately 20 dwelling units to the north east and approximately 44 dwelling units on the western sites. These sites would provide for a diversity of housing product within the urban cell.

The corner location of the grouped dwelling sites would encourage a high quality landmark design to complement that of the Neighbourhood Centre. The size of these lots would also allow sufficient space for communal open space with facades addressing all street frontages. These grouped dwelling sites will assist with generating the necessary resident base and activity required to sustain the future growth of the Neighbourhood Centre.

5.4.3 Lot Orientation

Given the current orientation and shape of the subject site, the proposed development will be able to maximise east-west/ north-south aligned lots. R30 lots are predominantly orientated north-south, with the lots facing east/west. R20 lots are predominantly east-west oriented, however, increased widths between 15m to 17m will be provided where orientation is along the north-south length.

Further climate responsive design can be facilitated through the built form and where appropriate can be included within DAPs.

5.5 Public Open Space

Under the provisions of Liveable Neighbourhoods a range of site responsive urban parkland is required, which appropriately addresses district, neighbourhood and local needs of residents, comprising a mixture of unrestricted and restricted open space.

The subject site comprises a total site area of 11.4474 hectares, which includes a gross subdivisible area of 10.8877 hectares (minus Rowley Road and drainage reserve). At this stage, a total land area of approximately 10,888m² has been set aside over three POS sites, being for active/passive recreation and drainage purposes. These sites are approximately 2,577m², 4,452m² and 5,712m² in size.

Whilst Liveable Neighbourhoods provides for a minimum contribution of 10% of the gross subdivisible area as POS, a minimum of 8% is required for active and passive recreational purposes where the remaining 2% may comprise of restricted use public open space. The proposed Local Structure Plan includes drainage areas greater than a 1 in 100 year event as restricted POS. The smaller POS areas fronting Rowley Road (south), which will have a drainage component, are within the 2% allowance.

The sizes of the proposed POS sites allow for the capacity to accommodate both passive and active recreation facilities. Further, the proposed parks are within the recommended 400 metre walkable distance from all proposed residential dwellings in the LSP area in accordance with Liveable Neighbourhoods.

Public Open Space Schedule			
Site Area			11.4474 ha
Deductions			
Rowley Road widening	3,744m^2		
Dedicated Drainage Reserve (1 year ARI)	1,853m^2		
Total		5,597m^2	
Gross Subdivisible Area			10.8877 ha
POS @10%			1.0888 ha
Public Open Space Contribution			
May comprise:			
Min 80% unrestricted POS		8,710m^2	
Max 20% restricted use POS		2,178m^2	
Total Required POS			1.0888 ha
POS Reference Number	Unrestricted POS	Restricted POS	Total POS
1.	1,321m^2		0.1321ha
2.	3,597m^2	258m^2	0. 3855ha
3.	3,792m^2	1,920m^2	0.5712ha
TOTAL	**8,710m^2**	**2,178m^2**	**1.0888ha**

The areas of the open space are notional only and will be subject to detailed design. These will be updated during the subdivision process. The subdivision design will ensure that the minimum requirement of 10% is provided.

A Landscape Master Plan will be submitted at a later stage including details of the landscaping, recreation facilities, footpaths, street furniture, etc.

5.6 Urban Water Management

5.6.1 Assessment of Birrega Main Drain Realignment

JDA Consultant Hydrologists have undertaken an assessment of the proposed realignment of the Birrega Main Drain (refer to LWMS in Appendix 5). The report investigates the realignment of the Birrega Main Drain within the subject site that is required to accommodate the future downstream realignment of the Birrega Main Drain as detailed in the approved WUW Master Plan.

The realignment is proposed to assist in achieving planning outcomes within the WUW Master Plan area, in particular linking the Birrega Main Drain to areas of significant vegetation protection, while also improving the existing hydraulic performance of the Birrega Main Drain. The proposed realignment in the subject site is consistent with the WUW Master Plan and represents the first stage of its realignment to Tonkin Highway.

5.6.2 Local Water Management Strategy

A Local Water Management Strategy ("LWMS") has been prepared in support of the proposed LSP and is attached as Appendix 5.

A summary of key elements proposed in the LWMS are set out in the table below.

Principle	Key LWMS Elements
Water Quantity To maintain the total water cycle balance within development areas relative to the pre-development conditions	» Maintain flow paths for existing catchments » Maintain 1 in 1 year ARI event post development discharge volume and peak flow rates relative to predevelopment conditions Maintain 5 and 100 year ARI peak flows from the Study Area to at or below current discharge levels » Stormwater detention area outlets set at defined CGL » Maximise infiltration opportunities
Water Quality To maintain or improve the surface and groundwater quality within development areas relative to pre-development conditions	» Maintain 1 in 1 year ARI event post development discharge volume and peak flow rates relative to predevelopment conditions » Bioretention areas to be set at 2% of the equivalent impervious area of development » Relocation and rehabilitation of Birrega Main Drain » Use of treatment train approach to stormwater management » Application of source controls – including street sweeping, education to reduce nutrient application, native plantings, swales, passive POS areas, lot soakwells » Application of structural controls – retention/detention areas, gross pollutant trapping devices, swales » Post development monitoring program and performance review process
Water Conservation To maximise the reuse of stormwater	» Implement water efficiency and demand management measures in and exhouse » Use of native plantings in POS areas and passive POS areas to minimise irrigation
Ecosystem Health To retain natural drainage systems and protect ecosystem health	» Relocation and rehabilitation of Birrega Main Drain » Relocation of Birrega to enable habitat and vegetation linkage downstream of the Study Area » Gross pollutant trapping devices to be installed on outlets
Economic Viability	» Use of proven structural WSUD technology

To implement stormwater systems that are economically viable in the long term	» Use of source control techniques to minimise cost of nutrient management
Public Health To minimise the public risk, including risk of injury or loss of life to the community	» Design in accordance with relevant design standards, best management practices, council regulations and government agency requirements
Protection of Property To protect the built environment from flooding and waterlogging	» Provision of 100 year ARI flood protection for Study Area » Protection of downstream areas by restricting stormwater discharge to existing levels for storm events up to 100 year ARI » Subsoil drainage to be implemented to control seasonal groundwater rise to the defined CGL
Social Values To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater	» Relocation and rehabilitation of Birrega Main Drain » Integration of drainage and POS functions
Development To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles	» Urban water management in accordance with Better Urban Water Management (WAPC, 2008) » Development of the LWMS in accordance with government agency guidelines and best management practice recommendations » Use outcomes of continuing pre development and post development monitoring programs to help guide future water management

5.7 Services

The proposed urban development area will be provided with full services in a high standard of development. Cardno Gilbert Rose Consulting Engineers have provided the following summary of engineering requirements.

5.7.1 Water Supply

In the Water Corporation ultimate scheme the subject site will be serviced by the extension of a 500/400mm trunk main along Eight Road.

It should be noted that the existing 250mm in Vermilion Road has a limited spare capacity.

A temporary water supply could become available to service the first stage of this development (i.e. approximately 45-50 lots) from Vermilion Road.

Water supply to this area will be boosted at the time of extension of trunk mains and the remaining lots could be serviced after completion of these infrastructure works.

5.7.2 Wastewater Disposal

In Water Corporation's ultimate scheme wastewater from the subject site will be gravitated into a future pumping station in Hilbert Road at the intersection with Vermilion Road. It should noted that pre-funding a Type 40 or a Type 90 wastewater pumping station and a pressure main discharging to the treatment plant at Waterworks Road would be required.

5.7.3 Power Supply

All electrical power reticulation to the proposed development area will be underground in accordance with WAPC Policy.

The existing high voltage aerial network on three roads surrounding the subdivision provides the necessary infrastructure to service the subject site.

5.7.4 Telecommunications

The subject site could be serviced from the extension of existing infrastructure network in Hilbert Road and Rowley Road.

5.7.5 Alinta Gas

There is no Alinta Gas infrastructure currently available within the vicinity of the subject site.

The nearest point of medium pressure network is located in Wungong Road within the vicinity of Ninth Road. The gas main may be extended to service the subject site at the expense of the developer.

5.8 Detailed Area Plans

Detailed Area Plans ("DAP") present the opportunity to achieve better residential design outcomes, especially in relation to smaller lot sizes. Therefore DAPs will be prepared for:

- Lots where it is important to control vehicle access;
- Lots abutting POS;
- Lots with an area of less than 350m^2;
- Laneway lots;
- Lots in the immediate vicinity of Hopkinson and Rowley Roads;
- Lots identified as having a potential noise impact from traffic; and
- Grouped Dwelling sites.

The DAP's will include details of garage location, setback, dwelling frontage and additional site specific development requirements.

DAP's will be submitted, as required, to enable the clearance of the conditions of subdivision approval.

5.9 Staging

Given the size and scope of the development it is not proposed to implement a formal staging program for the implementation of this LPS.

Notwithstanding the above however, it is acknowledged the development will most likely occur in a logical progression with the construction and establishment of the services to be provided to the subject site, as discussed previously.

6.0 Conclusion

The LSP provides a planning framework to guide the urban development of the subject site. The proposed land uses and subdivision layout are consistent with the planning context provided under the MRS and TPS 2. The LSP design has been guided by the principles of Liveable Neighbourhoods.

The preparation of this LSP has been guided by an analysis of the opportunities and constraints within the subject site. The new POS sites will result with the rehabilitation of vegetation within the subject site and the realignment of the Birrega Main Drain will improve the drainage of the catchment area.

Development within the future Neighbourhood Centre catchment has been maximised through the allocation of higher densities and grouped dwelling sites to address a number of street frontages. Residential densities surrounding this catchment have been provided at densities ranging between R20 to R40.

The information provided within this report, reflects that the subject site is capable of being suitably developed for urban purposes. Suitable provisions of POS site have been made. These facilities are connected to the surrounding areas through an integrated road layout. Servicing requirements including roads and utilities have been adequately addressed.

APPENDIX 1

CERTIFICATES OF TITLE

REGISTER NUMBER	
1/D50969	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
2	**8/9/2006**

WESTERN AUSTRALIA

RECORD OF CERTIFICATE OF TITLE

UNDER THE TRANSFER OF LAND ACT 1893

VOLUME	FOLIO
1449	**531**

The person described in the first schedule is the registered proprietor of an estate in fee simple in the land described below subject to the reservations, conditions and depth limit contained in the original grant (if a grant issued) and to the limitations, interests, encumbrances and notifications shown in the second schedule.

BG Roberts

REGISTRAR OF TITLES

LAND DESCRIPTION:

LOT 1 ON DIAGRAM 50969

REGISTERED PROPRIETOR:

(FIRST SCHEDULE)

DENEVA PTY LTD OF 12 GAYTON ROAD, CITY BEACH

(T J348562) REGISTERED 4 JULY 2005

LIMITATIONS, INTERESTS, ENCUMBRANCES AND NOTIFICATIONS:

(SECOND SCHEDULE)

1. J893003 MORTGAGE TO ST. GEORGE BANK LTD REGISTERED 29.8.2006.

Warning: A current search of the sketch of the land should be obtained where detail of position, dimensions or area of the lot is required.
* Any entries preceded by an asterisk may not appear on the current edition of the duplicate certificate of title.
Lot as described in the land description may be a lot or location.

--END OF CERTIFICATE OF TITLE--

STATEMENTS:

The statements set out below are not intended to be nor should they be relied on as substitutes for inspection of the land and the relevant documents or for local government, legal, surveying or other professional advice.

SKETCH OF LAND:	1449-531 (1/D50969).
PREVIOUS TITLE:	1449-530.
PROPERTY STREET ADDRESS:	1242 ROWLEY RD, DARLING DOWNS.
LOCAL GOVERNMENT AREA:	SHIRE OF SERPENTINE-JARRAHDALE.

REGISTER NUMBER	
2/D50969	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
2	**8/9/2006**

WESTERN AUSTRALIA

RECORD OF CERTIFICATE OF TITLE

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B G Roberts

REGISTRAR OF TITLES

LAND DESCRIPTION:

LOT 2 ON DIAGRAM 50969

REGISTERED PROPRIETOR:

(FIRST SCHEDULE)

DENEVA PTY LTD OF 12 GAYTON ROAD, CITY BEACH

(T J461990) REGISTERED 7 OCTOBER 2005

LIMITATIONS, INTERESTS, ENCUMBRANCES AND NOTIFICATIONS:

(SECOND SCHEDULE)

1. J893003 MORTGAGE TO ST. GEORGE BANK LTD REGISTERED 29.8.2006.

Warning: A current search of the sketch of the land should be obtained where detail of position, dimensions or area of the lot is required.
* Any entries preceded by an asterisk may not appear on the current edition of the duplicate certificate of title.
Lot as described in the land description may be a lot or location.

---END OF CERTIFICATE OF TITLE---

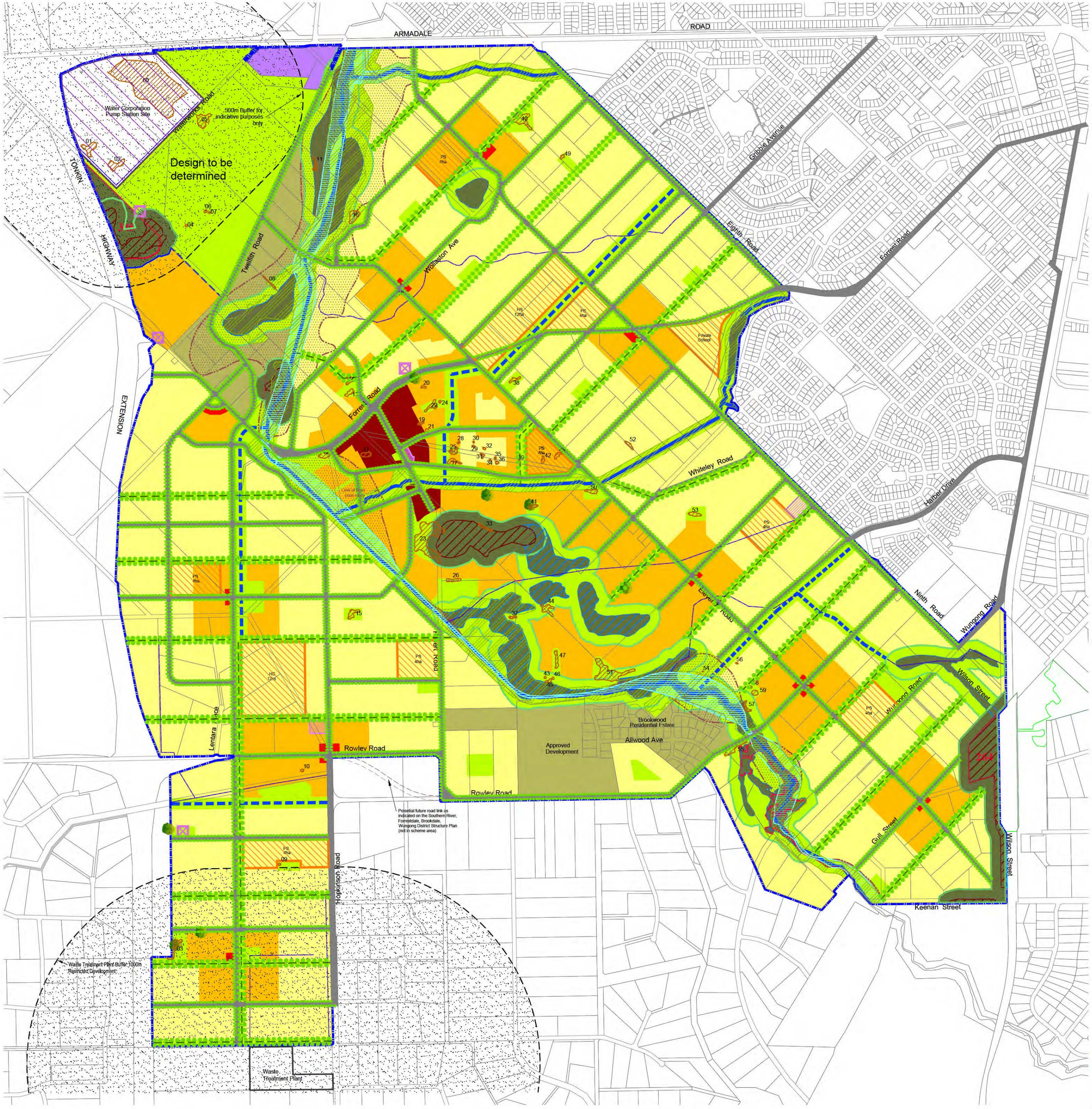
STATEMENTS:

The statements set out below are not intended to be nor should they be relied on as substitutes for inspection of the land and the relevant documents or for local government, legal, surveying or other professional advice.

SKETCH OF LAND:	1449-532 (2/D50969).
PREVIOUS TITLE:	1449-530.
PROPERTY STREET ADDRESS:	NO STREET ADDRESS INFORMATION AVAILABLE.
LOCAL GOVERNMENT AREA:	SHIRE OF SERPENTINE-JARRAHDALE.

APPENDIX 2

WUNGONG URBAN WATER MASTER PLAN



LEGEND

▭ Scheme & Master Plan Area

PLACE CODES

🟥 Town Activity Centre

🟥 Neighbourhood Activity Centre

🟪 Commercial

▨ Infrastructure

🟧 Urban

🟨 Suburban

🟫 Rural Residential

🟩 Active Open Space

🟩 Passive Open Space

MASTER PLAN ELEMENTS

Road Avenue (Road with avenues of trees)

Park Avenue (Linear parkland with avenue of trees)

▨ Conservation Category Wetland

Edge of Buffer Area

River or Brook

Living Stream

Floodway

▨ Community Centre

264 Bush Forever site

● Scarred Tree (To be assessed for potential aboriginal heritage value)

☒ Registered Aboriginal Heritage Sites (Buffer set by Department of Indigenous Affairs)

▨ Resource Enhancement Wetland

▨ Foreshore Buffer

Current Watercourse prior to relocation

Floodplain

▨ School

Identified Archaeological Site

NOTE:

1. Where an archeological site is not included in an Open Space area, the intent for a section 18 application to be made to remove the site with material salvaged.
2. Threatened ecological communities and EPP Lakes exist in some designated protection areas. Refer to environmental report.
3. Wungong River and Neerigen Brooks are registered Aboriginal sites (Department of Indigenous Affairs site 3512 and 3714 respectively). The reported boundaries of these sites have been omitted from the Master Plan for purposes of clarity.

Wungong Urban Water Master Plan

Incorporating ;
Amendment No. 1 Gazetted December 2008
Amendment No. 3 Gazetted December 2008
Amendment No. 5 Gazetted July 2009

Armadale
the natural place to grow

Armadale
Redevelopment Authority

N

Plan modified
September 2009
GIS Office
City of Armadale

Scale 1:10 000 @ A1
0 500 1000m

P:\AutoCAD\ARA\05122008\Wungong_Urban_Water_Master_Plan.dwg

SJS TRIM - IN12/8716

APPENDIX 3

ADJOINING STRUCTURE PLANS

LEGEND

- 🟥 SUBJECT SITE
- 🟪 CELL 1B LSP (DYKESTRA PLANNING)
- 🟦 CELL K LSP (TAYLOR BURREL BARNETT)

date	5 June 2012	job no.	4678	scale	1: 5000 @ A2
designer	S Armstrong	prepared by	M Callaghan	e-ref	051201
client				projection	

peel

Level 2, 69 Pinjarra Road, Mandurah, Western Australia, 6210
email mandurah@greg-rowe.com web greg-rowe.com tel +618 9582 8288 fax +618 9581 2588

title surrounding structure plans

address lots 1 and 2 rowley road
darling downs

PERTH • PEEL / SOUTH WEST • MID WEST • PILBARA

GREG ROWE & associates
FOCUSED ON ACHIEVEMENT

N

SJS TRIM - IN12/8716

APPENDIX 4

FLORA AND VEGETATION SURVEY

FLORA AND VEGETATION SURVEY
LOTS 1 & 2 HILBERT ROAD
BROOKDALE

On behalf of:
SPM PROJECT MARKETING

Prepared by:
ENV Australia
ACN 091 839 520
Level 7
182 St Georges Terrace
Perth WA 6000
Telephone (08) 9289 8360 Facsimile (08) 9322 4251

06.149/RP001 Sep 2006	FINAL Approved for Issue: RP

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STATEMENT OF LIMITATIONS

Scope of Services

This environmental site assessment report ("the report") has been prepared in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and ENV.Australia Pty Ltd (ENV) ("scope of services"). In some circumstances the scope of services may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints.

Reliance on Data

In preparing the report, ENV has relied upon data, surveys, analyses, designs, plans and other information provided by the Client and other individuals and organisations, most of which are referred to in the report ("the data"). Except as otherwise stated in the report, ENV has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report ("conclusions") are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. ENV will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to ENV.

Environmental Conclusions

In accordance with the scope of services, ENV has relied upon the data and has conducted environmental field monitoring and/or testing in the preparation of the report. The nature and extent of monitoring and/or testing conducted is described in the report.

Within the limitations imposed by the scope of services, the monitoring, testing, sampling and preparation of this report have been undertaken and performed in a professional manner, in accordance with generally accepted practices and using a degree of skill and care ordinarily exercised by reputable environmental consultants under similar circumstances. No other warranty, expressed or implied, is made.

Report for Benefit of Client

The report has been prepared for the benefit of the Client and no other party. ENV assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including without limitation matters arising from any negligent act or omission of ENV or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own enquiries and obtain independent advice in relation to such matters.

Other Limitations

ENV will not be liable to update or revise the report to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.

The scope of services did not include any assessment of the title to or ownership of the properties, buildings and structures referred to in the report nor the application or interpretation of laws in the jurisdiction in which those properties, buildings and structures are located.

EXECUTIVE SUMMARY

ENV. Australia Pty Ltd (ENV) was commissioned by SPM Project Marketing to undertake a flora and vegetation assessment for Lots 1 and 2 Hilbert Road, Brookdale. The work focussed on determining vegetation communities present, locating Declared Rare and Priority Flora and Threatened Ecological Communities, as well as conducting a condition assessment of the existing flora.

A total of 15 families, 29 genera and 34 taxa were recorded in the survey area, of which 29 were introduced species. No plant taxa gazetted as Declared Rare pursuant to subsection (2) of section 23F of the Wildlife Conservation Act (1950) or Priority Flora species were located during the field survey. No Endangered or Vulnerable species, pursuant to s178 of the Environmental Protection and Biodiversity Conservation Act (1999) were located during the survey.

Native vegetation at the site had been totally cleared and only minimal regrowth of five native species was present on the site. The site was dominated by pasture species and other weeds. The condition of vegetation at the site was Completely Degraded. Consequently, there were no Threatened Ecological Communities found at the site.

ENV did not find any obvious impediments to development of the site.

1 INTRODUCTION

ENV. Australia Pty Ltd (ENV) was commissioned by SPM Project Marketing to undertake a flora and vegetation assessment for Lots 1 & 2 Hilbert Rd, Brookdale. The site is predominantly cleared and used for grazing horses.

Lots 1 & 2 cover an approximate area of 11 ha and have been totally cleared. It is our understanding that an assessment of vegetation is required, to examine the potential constraints that vegetation on the site may pose for a redevelopment application for the site. This document presents the results of this assessment.

This report comprises a spring Declared Rare and Priority Flora survey as well as a general flora and vegetation survey.

1.1 LOCATION

Lots 1 & 2 Hilbert Rd are approximately 27 km south-east of Perth in the suburb of Brookdale, within the City of Armadale. The site is bound by Rowley Road on the south and west sides, by the Rowley Road road-reserve to the north and by Hilbert Road on the east side.

The site is located in the southwest province of Western Australia in the Darling Botanical District. This region typically consists of forest country with related woodlands and is divided into four subregions or botanic subdistricts.

Lots 1 & 2 are located within the Swan Coastal Plain Subregion in the Drummond Botanical Subdistrict, which consists mainly of the following vegetation communities:

- Banksia Low Woodland on leached sands and Melaleuca Swamps in poorly drained areas.
- Woodland of Tuart (*Eucalyptus gomphocephala*); and
- Jarrah (*Eucalyptus marginata*) and Marri (*Corymbia calophylla*) on the less leached soils (Beard, 1990).

The climate of this region is Warm Mediterranean, with winter precipitation of 600-1000 mm and 5-6 dry months per year.

1.2 DECLARED RARE AND PRIORITY FLORA

Flora species acquire Declared Rare or Priority conservation status where populations are geographically restricted or threatened by local processes. The Department of Environment and Conservation (previously CALM) enforces regulations under the *Wildlife Conservation Act (1950)* to conserve Declared Rare Flora and protect significant populations.

Rare Flora species are gazetted under Subsection 2 of Section 23F of the *Wildlife Conservation Act* (1950) and therefore it is an offence to "take" or damage rare flora without Ministerial approval. Section 23F of the Wildlife Conservation Act (1950-1980) defines "to take" as to: 'gather, pick, cut, pull up, destroy, dig up, remove or injure the flora or to cause or permit the same to be done by any means'.

Priority Flora are under consideration for declaration as 'rare flora', but are in urgent need of further survey (Priority One to Three) or require monitoring every 5-10 years (Priority Four) (see Appendix A for definitions).

Flora is also classified according to their conservation status at a federal level, under the *Environmental Protection and Biodiversity Conservation Act*, 1999 (EPBC Act). The EPBC Act is administered by the Department of Environment and Heritage. These categories of classification are summarised in Appendix A.

1.3 THREATENED ECOLOGICAL COMMUNITIES

A vegetation community is considered a Threatened Ecological Community (TEC) if it is found to fit into one of the following categories:

- Presumed Totally Destroyed;
- Critically Endangered;
- Endangered; or
- Vulnerable

The definitions of these categories are described in Appendix B.

Coordination of threatened species and ecological community conservation is carried out by Department of Environment and Conservation's Nature Conservation Division, primarily through the Western Australian Threatened Species and Communities Unit (WATSCU). TECs are not protected by State Government legislation, however, several Western Australian TECs are listed and formally protected under the Commonwealth *Environment Protection and Biodiversity Conservation Act*, 1999 (refer to section 1.4 for further detail about listing of TECs).

1.4 LISTING OF THREATENED FLORA AND VEGETATION

The Wildlife Conservation Act provides for taxa of plants and animals to be listed as ‘threatened’. CALM Policy Statements Nos 9 *Conservation of threatened flora in the wild* and 33 *Conservation of endangered and specially protected fauna in the wild* cover this area.

Threatened flora and vegetation lists are reviewed and changes recommended by Department of Environment and Conservation’s Threatened Species Scientific Committee. Ministerial approval is necessary before changes are given legal status in a notice in the Government Gazette.

There is currently no equivalent legislation or formal policy for the protection of threatened ecological communities, however, an informal, non-statutory process, including advice from a scientific advisory committee, the establishment of the threatened ecological communities database, and steps for assigning ecological communities to categories of threat, is now in place.

The Department has been identifying and informally listing threatened ecological communities (TECs) for ten years. As of May 2003, 106 ecological communities had been entered into the Department's TEC Database. Of these, 21 have been endorsed by the Minister for the Environment as Critically Endangered, 17 as Endangered, 28 as Vulnerable and three as presumed totally destroyed. The remainder are either awaiting endorsement as threatened or are allocated to one of five priority lists. Sixteen TECs are now listed under the Commonwealth's EPBC Act.

Any person may nominate an ecological community for listing under the EPBC Act, 1999. Nominations are forwarded to the Threatened Species Scientific Committee. Once the Committee has conducted an assessment of the conservation status of the ecological community, its advice and subsequent recommendations are forwarded to the Minister for the Environment and Heritage who makes the final decision. The recommendations endorsed by the Minister in making a listing decision are provided via the EPBC Act lists.

2 SCOPE OF WORKS

The work focussed on determining vegetation communities present, locating Declared Rare and Priority flora and Threatened Ecological Communities, as well as conducting a condition assessment of the existing flora. Specifically, this comprised:

- A data base search for Rare and Endangered species and Threatened Ecological Communities (TECs) that may occur in the area, by reference to Department of Environment and Conservation (previously CALM) and Department of Environment and Heritage databases;
- A flora and vegetation field survey, including the establishment of 10x10m quadrats, to determine the presence of any DRF/ TECs;
- A search for rare and endangered flora contained within the defined area;
- Identification of any Threatened Ecological Communities (TECs);
- The review of data collected against criteria established in state and federal processes for species conservation;
- The production of an aerial photograph with vegetation mapping overlaid; and
- A final report that describes the results from the above, the potential constraints that may be posed by the vegetation given the available information and recommendations for further work.

3 METHODS

The methodology for the work involved the following key steps:

PHASE 1

On the 15th August 2006 a database search request was submitted to the Department of Environment and Conservation to obtain a list of Declared Rare and Priority Flora species and Threatened Ecological Communities (TECs) that occur within the surrounding area of the subject site. The search was within co-ordinates from 397695E 6434193N to 408695E 6445872N (GDA94) (CALM, 2006 Department's *Threatened (Declared Rare) Flora* database).

PHASE 2

On the 31st October and 2nd November 2006 an ENV botanist visited the site and conducted a vegetation survey by traversing the property on foot. Data was collected from a 10 x 10 m quadrat, a photo was taken, the vegetation community was described and a condition statement made.

PHASE 3

Where field identification of plant taxa was not possible, specimens were collected in a systematic manner so that they could be later identified at the West Australian Herbarium by comparison with the reference collection and use of identification keys.

4 RESULTS

The following results are accurate at the time of report preparation. Flora composition changes over time with flora species having specific growing periods, especially annuals and ephemerals (some plants lasting for a markedly brief time, some only a day or two). For this reason the outcome of future botanical surveys undertaken on the properties have the potential to change.

4.1 DATABASE SEARCH

A database search of the area resulted in 7 Declared Rare and 30 Priority Flora species being identified as potentially occurring in the area. The species are:

Table 1: Showing Declared Rare/Priority Flora Species Occurring Within the Site Area

Family	Taxa	Conservation Code: FEDERAL	Conservation Code: STATE
Amaranthaceae	*Ptilotus sericostachyus* subsp*. roseus*	Not Listed	1
Anthericaceae	*Johnsonia pubescens* subsp. *cygnorum*	Not Listed	2
Anthericaceae	*Thysanotus glaucus*	Not Listed	4
Apiaceae	*Eryngium pinnatifidum* subsp. *palustre* ms	Not Listed	3
Asteraceae	*Rhodanthe pyrethrum*	Not Listed	3
Asteraceae	*Trichocline* sp.Treeton	Not Listed	2
Byblidaceae	*Byblis gigantea*	Not Listed	2
Centrolepidaceae	*Centrolepis caespitosa*	Not Listed	4
Cyperaceae	*Lepidosperma rostratum*	Endangered	R
Cyperaceae	*Schoenus pennisetis*	Not Listed	1
Dilleniaceae	*Hibbertia montana*	Not Listed	4
Droseraceae	*Drosera occidentalis* subsp. *occidentalis*	Not Listed	4
Goodeniaceae	*Anthotium junciforme*	Not Listed	4
Menyanthaceae	*Villarsia submersa*	Not Listed	4
Mimosaceae	*Acacia horridula*	Not Listed	3
Mimosaceae	*Acacia oncinophylla* subsp. *patulifolia*	Not Listed	2
Myrtaceae	*Calytrix simplex* subsp. *simplex*	Not Listed	1

Myrtaceae	*Eucalyptus balanites*	Endangered	R
Myrtaceae	*Verticordia lindleyi* subsp. *lindleyi*	Not Listed	4
Myrtaceae	*Verticordia plumosa* var. *pleiobotrya*	Endangered	R
Orchidaceae	*Caladenia huegelii*	Endangered	R
Orchidaceae	*Caladenia longicauda* subsp. *clivicola*	Not Listed	4
Orchidaceae	*Diuris purdiei*	Endangered	R
Orchidaceae	*Drakaea elastica*	Endangered	R
Orchidaceae	*Drakaea micrantha*	Vulnerable	R
Orchidaceae	*Thelymitra magnifica*	Not Listed	3
Papilionaceae	*Aotus cordifolia*	Not Listed	3
Papilionaceae	*Gastrolobium alternifolium*	Not Listed	3
Papilionaceae	*Jacksonia sericea*	Not Listed	4
Proteaceae	*Dryandra kippistiana* var. *paenepeccata*	Not Listed	3
Proteaceae	*Grevillea thelemanniana*	Not Listed	4
Proteaceae	*Hakea tuberculata*	Not Listed	3
Proteaceae	*Petrophile filifolia* subsp. *laxa*	Not Listed	2
Proteaceae	*Synaphea odocoileops*	Not Listed	1
Restionaceae	*Apodasmia ceramophila*	Not Listed	2
Stackhousiaceae	*Tripterococcus paniculatus*	Not Listed	1
Stylidiaceae	*Stylidium longitubum*	Not Listed	3

The CALM database search showed that there are five TECs within a five kilometre radius of the survey site (The information supplied by the Department of Conservation and Land Management is only an indication of the TECs that may be present). The five TECs are:

- **SCP3a: *Corymbia calophylla - Kingia australis* woodlands on heavy soils, Swan Coastal Plain** is listed as Critically Endangered by the WA Threatened Species and Communities Unit – endorsed by the Minister for the Environment, and listed as Endangered under the Environmental Protection and Biodiversity Conservation (EPBC) Act (1999).

- **SCP3c: *Corymbia calophylla - Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain** is listed as Critically Endangered by the

WA Threatened Species and Communities Unit – endorsed by the Minister for the Environment, and listed as Endangered under the EPBC Act (1999).

- **SCP20b: *Banksia attenuata* and/or *Eucalyptus marginata* woodlands of the eastern side of the Swan Coastal Plain** is listed as Endangered by the WA Threatened Species and Communities Unit – endorsed by the Minister for the Environment, however, is not listed under the EPBC Act (1999).
- **SCP08: Herb rich shrublands in clay pans** is listed as Vulnerable by the WA Threatened Species and Communities Unit – endorsed by the Minister for the Environment, however, is not listed under the EPBC Act (1999).
- **SCP10a: Shrublands on dry clay flats** is listed as Endangered by the WA Threatened Species and Communities Unit – endorsed by the Minister for the Environment, however, is not listed under the EPBC Act (1999).

See Appendix B for the definitions of Threatened Ecological Community conservation categories.

4.2 FIELD SURVEY

4.2.1 Flora

A total of 15 families, 29 genera and 34 taxa were recorded in the survey area, of which 29 were introduced species (see Appendix C).

The dominant plant families recorded from the survey were as follows:

- Poaceae
- Boraginaceae
- Asteraceae, and
- Papilionaceae.

To successfully record all species from an area surveys should be undertaken several times throughout the year. The majority of species occur through spring, however there are some species that occur at different times of year, for example, RESTIONACEAE and CYPERACEAE families flower in autumn.

4.2.2 Rare and Priority Flora

No plant taxa gazetted as Declared Rare pursuant to subsection (2) of section 23F of the Wildlife Conservation Act (1950) or Priority Flora species (Atkins, 2006) were located during the field survey.

No Endangered or Vulnerable species, pursuant to s178 of the Environmental Protection and Biodiversity Conservation Act, 1999 were located during the survey.

4.2.3 Vegetation

The native vegetation at the site had been totally cleared and replaced by pasture species and weeds. Only five native species remained at the site (Refer to Appendix D for site photos).

4.2.4 Vegetation Condition

The condition of vegetation throughout the site was Totally Degraded, with few native species remaining and the site dominated by very aggressive weeds.

The condition scale commonly used in the Perth metropolitan area and Bush Forever, Keighery B. J. 1994, was used for this assessment due to it providing a standardised scaling system that is widely known by government agencies. The definition of the condition scales are in Appendix E.

4.2.5 Introduced Species

The Environmental Weed Strategy for Western Australia contains criteria for the assessment and ranking of weeds in terms of their environmental impact on biodiversity. These criteria are as follows:

- **Invasiveness –** ability to invade bushland in good to excellent condition or ability to invade waterways. (Score as yes or no).
- **Distribution** – wide current or potential distribution including consideration of known history of wide spread distribution elsewhere in the world. (Score as yes or no).
- **Environmental Impacts** – ability to change the structure, composition and function of ecosystems. In particular an ability to form a monoculture in a vegetation community. (Score as yes or no).

The rating of each weed is determined by the following scoring system:

- **High** - a weed species would have to score yes for all three criteria. Rating a weed species as high would indicate prioritising this weed for control and/or research i.e. prioritising funding to it.
- **Moderate** -a weed species would have to score yes for two of the above criteria. Rating a weed species as moderate would indicate that control or research effort should be directed to it if funds are available, however it should be monitored (possibly a reasonably high level of monitoring).
- **Mild** – a weed species scoring one of the criteria. A mild rating would indicate monitoring of the week and control where appropriate.
- **Low** – a weed species would score none of the criteria. A low ranking would mean that this species would require a low level of monitoring.

The table below contains the dominate weed species identified during the field survey with their ratings and criteria according to the Environmental Weed Strategy.

Table 2: Dominant Weed Species Identified

Taxon	**Common Name**	**Criteria**			
		Rating	**Invasiveness**	**Distribution**	**Impacts**
**Lolium rigidum*	Annual rye grass	Moderate	Yes	Yes	No
**Arctotheca calendula*	Cape weed	Moderate	Yes	Yes	No
**Lotus subbiflorus*	Hairy birdsfoot trefoil	Low	No	No	No
**Echium plantagineum*	Patterson's curse	TBA			

Plants may be "declared" by the Agriculture Protection Board under the Agriculture and Related Resources Protection Act, 1979. Declared Plants are gazetted under 5 categories (P1 – P5), which define the action required. The category may apply to the whole state, districts, individual properties or even paddocks. If a plant is declared, all landholders are obliged to control that plant on their properties. (Department of Agriculture, 2004).

There were three Declared Plant species found within the study area. These were:

- **Echium plantagineum* (declared P1 for the whole of the state),
- **Gomphocarpus fruticosus* (not declared within the Perth metropolitan area, and
- **Moraea miniata* (declared P1 for the whole of the state).

Category P1 prohibits movement. The movement of plants or their seeds is prohibited within the State. This prohibits the movement of contaminated machinery and produce including livestock and fodder.

5 DISCUSSION

The subject site does not support any Declared Rare Flora taxa pursuant to subsection (2) of section 23F of the Wildlife Conservation Act (1950) or Priority Flora species (Department of Environment and Conservation 2006). The survey was conducted during spring to maximise the opportunity for the full suite of potential species (ephemerals/ annuals) to emerge. Therefore this site is unlikely to support any flora taxa of significance as the survey was conducted at the appropriate time of year.

Lots 1 & 2 Hilbert Road comprise a relatively small area of cleared land in Totally Degraded condition with almost no native species remaining.

6 CONCLUSIONS AND RECOMMENDATIONS

It is concluded that:

- Lots 1 & 2 Hilbert Road contain 34 flora taxa, of which 5 are native;
- No DRF or Priority Flora taxa appear to occur at the site. This survey was conducted at the appropriate time of year therefore this statement can be made with a high level of reliability;
- No Threatened Ecological Communities occur at the site, which has been totally cleared; and
- The condition of vegetation across the site is Totally Degraded, with little native vegetation remaining, and the presence of weedy pasture species;

ENV considers that the proposed development application can be submitted, given the results of the above.

Birriga drain passes through Lot 2. This is a Main Drain so it is recommended that the Water Corporation be contacted regarding any planning constraints surrounding this drain.

7 REFERENCES

Atkins, K.J. (2006). Declared Rare and Priority Flora List for Western Australia, 30 June 2006. Dept of Conservation and Land Management. Como, W.A.

Beard, J.S. (1990). Plant Life of Western Australia. Kangaroo Press.

Commonwealth of Australia (1999). Environmental Protection and Biodiversity Conservation Act.

Department of Conservation and Land Management (1992). Policy Statement 9: Conservation of Threatened Flora in the Wild.

Government of Western Australia (1950). Wildlife Conservation Act.

WA Threatened Species and Communities Unit/ Conservation and Land Management (2001) Definitions, Categories and Criteria for Threatened and Priority Ecological Communities. Conservation and Land Management.

Western Australian Herbarium (2006). Florabase - Information on the Western Australian Flora. Department of Conservation and Land Management. http://www.calm.wa.gov.au/science/florabase.html

FIGURES

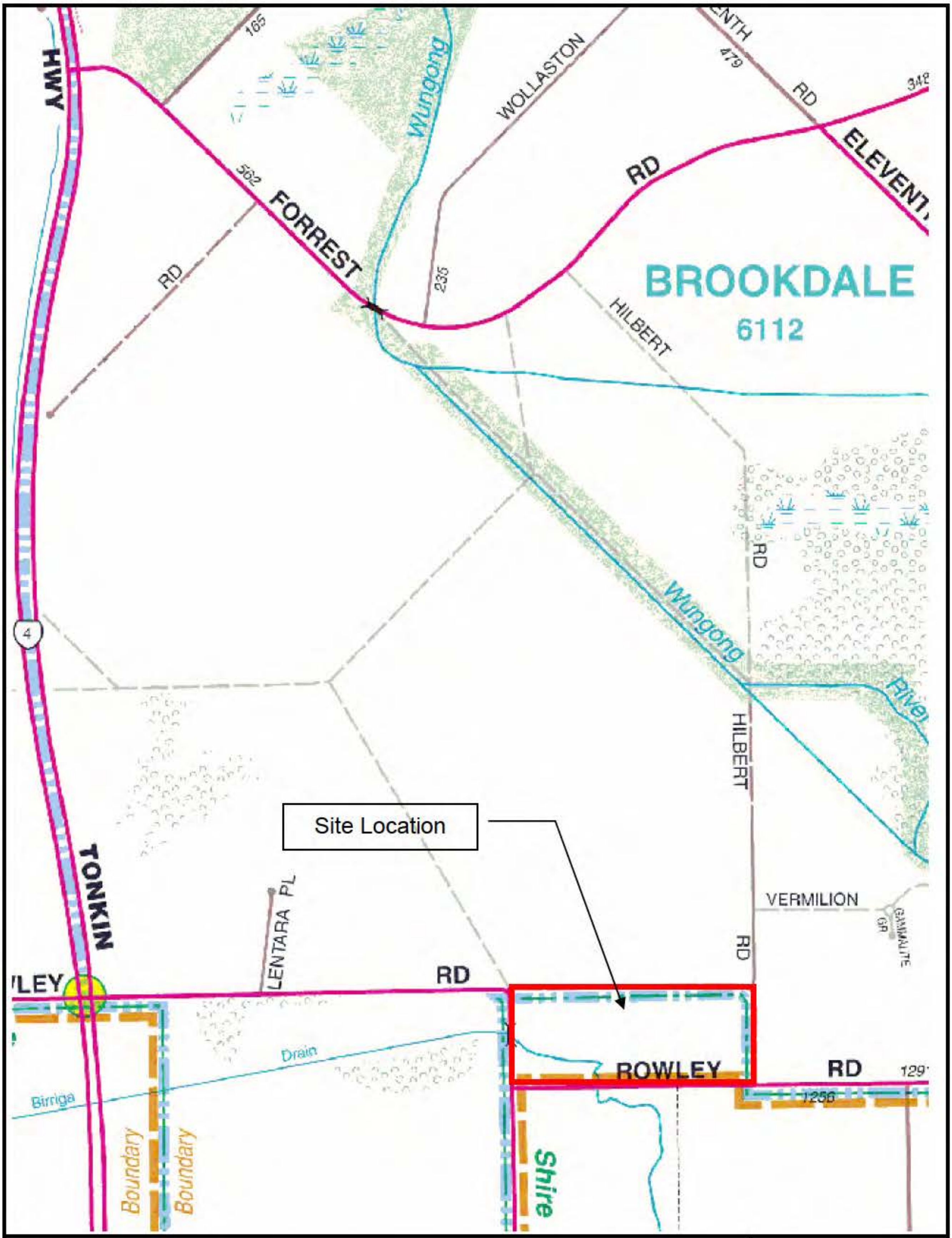

FIGURE 1: Site location

CLIENT: SPM Project Marketing

JOB NUMBER: 06.149

DATE: 15/8/2006

DRAWN BY: RP

CHECKED BY: ML

SCALE: NTS

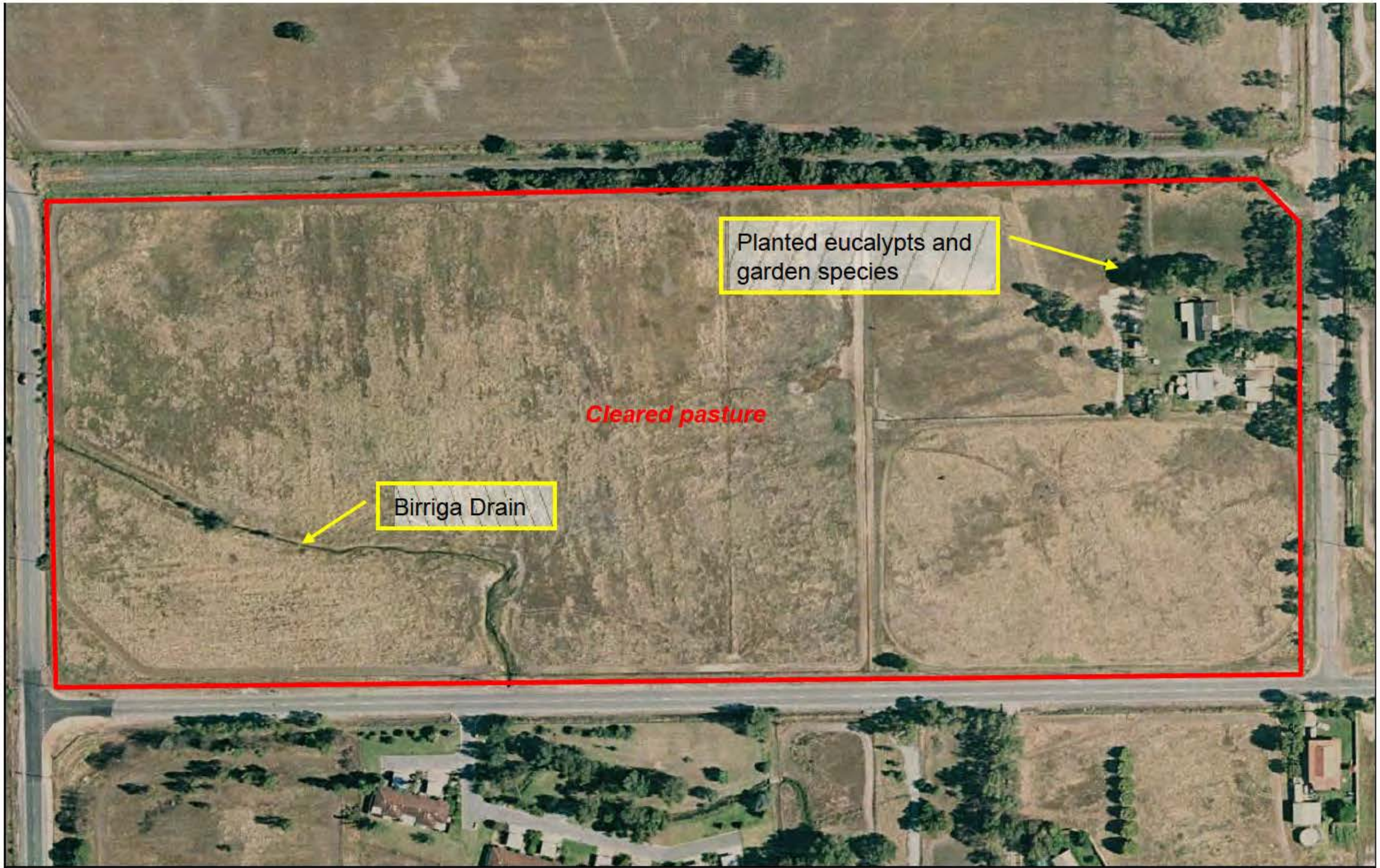

FIGURE 2: Vegetation map

CLIENT: SPM Project Marketing

DRAWN BY: RP

DATE: 26/11/2006

JOB NUMBER: 06.149

CHECKED BY: ML

env Australia

APPENDIX A

DEFINITIONS OF DECLARED RARE AND PRIORITY FLORA SPECIES

APPENDIX A
Definition of Rare and Priority Flora Species (Department of Conservation and Land Management, 2003)

Conservation Code	Category
R	Declared Rare Flora- Extant Taxa "Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection and have been gazetted as such"
X	Declared Rare Flora – Presumed Extinct Taxa Taxa which have not been collected, or otherwise verified, over the past 50 years despite thorough searching, or of which all known wild populations have been destroyed more recently, and have been gazetted as such.
P1	Priority One- Poorly Known Taxa "Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat, e.g. road verges, urban areas, farmland, active mineral leases, etc., or the plants are under threat, e.g. from disease, grazing by feral animals, etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as 'rare flora', but urgently need further survey."
P2	Priority Two- Poorly Known Taxa "Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but urgently need further survey."
P3	Priority three- Poorly Known Taxa "Taxa which are known from several populations, and the taxa are not believed to be under immediate threat (i.e. not currently endangered), or known populations being large, and either widespread or protected. Such taxa are under consideration for declaration as 'rare flora' but need further survey."
P4	Priority Four- Rare Taxa "Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5-10 years."

APPENDIX A

Categories of Threatened Flora Species (Environmental Protection and Biodiversity Conservation Act, 1999)

Category Code	Category
Ex	Extinct Taxa which at a particular time if, at the time, there is no reasonable doubt that the last member of the species has died**.**
ExW	Extinct in the wild Taxa which is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
CE	Critically Endangered Taxa which at a particular time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
E	Endangered Taxa which is not critically endangered and it is facing a very high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
V	Vulnerable Taxa which is not critically endangered or endangered and is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
CD	Conservation Dependent Taxa which at a particular time if, at that time, the species is the focus of a specific conservation program, the cessation of which would result in the species becoming vulnerable, endangered or critically endangered within a period of 5 years.

APPENDIX B

DEFINITIONS OF THREATENED ECOLOGICAL COMMUNITIES

APPENDIX B
Definitions of Threatened Ecological Communities

Presumed Totally Destroyed (PD)

An ecological community will be listed as presumed totally destroyed if there are no recent records of the community being extant **and either** of the following applies (A or B);

A) Records within the last 50 years have not been confirmed despite thorough searches or known or likely habitats **or**

B) All occurrences recorded within the last 50 years have since been destroyed.

Critically Endangered (CR)

An ecological community will be listed as **Critically Endangered** when it has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future. This will be determined on the basis of the best available information, by it meeting **any one or more** of the following criteria (A, B or C):

A) The estimated geographic range, and/or total area occupied, and/or number of discrete occurrences since European settlement have been reduced by at least 90% and **either or both** of the following apply (i or ii)

    i) geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is imminent (within approximately 5 years)

    ii) modification throughout its range is continuing such that in the immediate future (within approximately 5 years) the community is unlikely to be capable of being substantially rehabilitated.

B) Current distribution is limited, and **one or more** of the following apply (i, ii or iii):

    i) geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the immediate future (within approximately 5 years)

    ii) there are very few occurrences, each of which is small and/or isolated and extremely vulnerable to known threatening processes

    iii) there may be many occurrences but total area is very small and each occurrence is small and/or isolated and extremely vulnerable to known threatening processes

C) The ecological community exists only as highly modified occurrences which may be capable of being rehabilitated if such work begins in the immediate future (within approximately 5 years)

Endangered (EN)

An ecological community will be listed as **Endangered** when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future. This will be determined on the basis of the best available information, by it meeting **any one or more** of the following criteria (A, B or C):

A) The estimated geographic range, and/or total area occupied, and/or number of discrete occurrences since European settlement have been reduced by at least 70% and **either or both** of the following apply (i or ii)

  i) geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is likely in the short term (within approximately 10 years)

  ii) modification throughout its range is continuing such that in the short term future (within approximately 10 years) the community is unlikely to be capable of being substantially restored or rehabilitated.

B) Current distribution is limited, and **one or more** of the following apply (i, ii or iii):

  i) geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the short term future (within approximately 10 years)

  ii) there are very few occurrences, each of which is small and/or isolated and extremely vulnerable to known threatening processes

  iii) there may be many occurrences but total area is very small and each occurrence is small and/or isolated and extremely vulnerable to known threatening processes

C) The ecological community exists only as highly modified occurrences which may be capable of being rehabilitated if such work begins in the short term future (within approximately 10 years).

Vulnerable (VU)

An ecological community will be listed as **Vulnerable** when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction in the medium to long term future. This will be determined on the basis of the best available information, by it meeting **any one or more** of the following criteria (A, B or C):

A) The ecological community exists largely as modified occurrences which are likely to be capable of being substantially restored or rehabilitated.

B) The ecological community can be modified or destroyed and would be vulnerable to threatening processes, is restricted in area and/or range and/or is only found at a few locations.

C) The ecological community may still be widespread but is believed likely to move into a category of higher threat in the medium to long term future because of existing or impending threatening processes.

APPENDIX C

SPECIES LIST

FLORA SPECIES LIST

*: denotes introduced species

FAMILY		TAXA
Asclepidaceae	*	*Gomphocarpus fruticosus*
Asteraceae	*	*Arctotheca calendula*
Asteraceae	*	*Cotula coronopifolia*
Asteraceae	*	*Hypochaeris radicata*
Asteraceae	*	*Sonchus oleraceus*
Boraginaceae	*	*Echium plantagineum*
Caryophyllaceae	*	*Spergula arvensis*
Cyperaceae		*Baumea articulata*
Cyperaceae		*Lepidosperma longitudinale*
Geraniaceae	*	*Erodium cicutarium*
Haemodoraceae		*Haemodorum simplex*
Iridaceae	*	*Moraea miniata*
Iridaceae	*	*Romulea rosea*
Juncaceae		*Juncus kraussii*
Juncaceae	*	*Juncus* sp.
Lobeliaceae	*	*Monopsis debilis*
Lythraceae	*	*Lythrum hyssopifolia*
Myrtaceae		*Eucalyptus rudis*
Myrtaceae	*	*Eucalyptus* spp. (planted)
Papillionaceae	*	*Lotus subbiflorus*
Poaceae	*	*Avena barbata*
Poaceae	*	*Avena sativa*
Poaceae	*	*Briza maxima*
Poaceae	*	*Briza minor*
Poaceae	*	*Cynodon dactylon*
Poaceae	*	*Ehrharta calycina*
Poaceae	*	*Ehrharta longiflora*
Poaceae	*	*Hordeum leporinum*
Poaceae	*	*Lolium rigidum*
Poaceae	*	*Pennisetum clandestinum*
Poaceae	*	*Polypogon monspeliensis*
Poaceae	*	*Stenotaphrum secundatum*
Poaceae	*	*Vulpia myuros*
Polygonaceae	*	*Rumex* sp.

APPENDIX D
SITE PHOTOS

Photo 1. Site of Quadrat 1

APPENDIX E

BUSH FOREVER CONDITION SCALES

APPENDIX C
Vegetation Condition Scales commonly used in Perth Metropolitan Region (Bush Forever)

Condition scale used in BUSH FOREVER VOL 2, from Keighery BJ (1994)	Condition scale used to derive Keighery BJ (1994) and Connell (1995) after Trudgen (1991)	Condition scale used in PEP MAPPING after Connell (1995)
Pristine (1) Pristine or nearly so, no obvious signs of disturbance	**Excellent (E)** Pristine or nearly so, no obvious signs of damage caused by the activities of European man.	No equivalent unit.
Excellent (2) Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.	**Very Good (VG)** Some relatively slight signs of damage caused by the activities of European man. For example, some signs of damage to tree trunks caused by repeated fires and the presence of some relatively non-aggressive weeds such as *Ursinia anthemoides* or *Briza* species, or occasional vehicle tracks.	**Very Good (VG)** Evidence of localised low level damage to otherwise healthy bush. Seedling recruitment and generally healthy population size (age/stage) structure apparent. Weed and grazing damage is confined (<20% of area). Some modification to vegetation structure due to changes in fire regimes may be apparent. Evidence of logging or firewood collection may be found. High likelihood that vegetation structure and species richness can be maintained.
Very Good (3) Vegetation structure altered, obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.	**Good (G)** More obvious signs of damage caused by the activities of European man, including some obvious impact on the vegetation structure such as caused by low levels of grazing or by selective logging. Weeds as above, possibly plus some more aggressive ones.	**Good (g)** Evidence of localised high level damage to otherwise low level damaged bush. Recruitment is localised and the populations of some species may be senescent. Weed and grazing damage is apparent in 20-50% of the area. Modification to vegetation structure due to changes in fire regimes may be apparent. Localised gall and parasitic plant damage may be apparent. Evidence of logging or firewood collection. Moderate likelihood that vegetation structure and species richness can be maintained.
Good (4) Vegetation structure significantly altered by very obvious signs of multiple disturbance. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.	**Poor (P)** Still retains basic vegetation structure or ability to regenerate to it after very obvious impacts of activities of European man such as grazing or partial clearing (chaining) or very frequent fires. Weeds as above, probably plus some more aggressive ones such as *Ehrharto* species.	**Poor (p)** Widespread high level damage. Recruitment is disrupted and most woody species appear senescent. Weed and grazing damage may be apparent throughout >50% of the area. Modification to vegetation structure due to changes in fire regimes may be apparent. Locally some vertical strata are absent. Gall and mistletoe damage apparent. Evidence of logging or firewood collection. Low likelihood that vegetation structure and species richness can be maintained or re-established.
Degraded (5) Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.	**Very Poor (VP)** Severely impacted by grazing, fire, clearing or a combination of these activities. Scope for some regeneration but not to a state approaching good condition without intensive management. Usually with a number of weed species including aggressive species.	**Very Poor (p)** Widespread high level damage. Recruitment is disrupted and most species appear senescent. Weed and grazing damage apparent throughout the area. Modification to vegetation structure due to changes in fire regimes apparent. Widespread loss of vertical strata. Gall and mistletoe damage apparent. Evidence of logging or firewood collection. Little to no likelihood that vegetation structure and species richness can be re-established.
Completely Degraded (6) The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.	**Completely Degraded (D)** Area that are completely or almost completely without native species in the structure of their vegetation, i.e. areas that are cleared or 'parkland cleared' with their flora comprising weed or crop species with isolated native trees or shrubs.	Not used – does not apply to bushland.

APPENDIX F
QUADRAT DATA SHEET

QUADRAT 1

GPS Datum: AUS84 **Easting:** 403069 mE **Northing:** 6438925 mN	**Date:** 2/11/2006	**Litter cover:** 2%
	Outcrop: nil	**Litter type:** leaves 2%
Topography: flat	**Rocks:** n/a	**Bare ground:** <1%
Soil Type: clay loam	**Aspect:** n/a	**Age since fire:** unknown
Soil colour: brown		**Disturbance:** High
Vegetation Description: Pasture (totally cleared)		

SPECIES PRESENT	HEIGHT (cm)	% COVER
**Echium plantagineum*	55	43
**Lotus subbiflorus*	20	50
**Lolium rigidum*	30	5
**Vulpia myuros*	20	1
**Romulea rosea*	10	<1
**Hypochaeris radicata*	25	<1
**Briza minor*	25	<1
**Arctotheca calendula*	20	<1
**Monopsis debilis*	6	<1

APPENDIX 5

LOCAL WATER MANAGEMENT STRATEGY

Terranovis

Lots 1 and 2 Rowley Road, Darling Downs
Local Water Management Strategy

March 2012

DISCLAIMER

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1. INTRODUCTION

1.1 Background

This document presents a Local Water Management Strategy (LWMS) in support of residential development for approximately 12 ha of land located at Rowley Rd, Darling Downs, in the Shire of Serpentine Jarrahdale. The Study Area is bordered on 3 sides by the southern boundary of the Armadale Redevelopment Authority's Wungong Urban Water Master Plan Area (Figure 1).

This document has been prepared to support the Local Structure Plan prepared by Greg Rowe and Associates for the abovementioned property in accordance with State Planning Policy 2.9. This document presents a recommended approach for total water cycle management within the proposed development area (herein referred to as the Study Area) consistent with sustainability principles.

The LWMS has been developed by JDA Consultant Hydrologists on behalf of the SPM Project Marketing. The compilation of this document has included a range of expertise and guidelines from leading authorities including the Department of Water (DoW), Water Corporation (WC), Armadale Redevelopment Authority (ARA), and Shire of Serpentine Jarrahdale (SSJ) to assist in achieving the implementation of best practice in sustainable urban development and urban water management within the Study Area.

The LWMS has been prepared consistent with the Armadale Redevelopment Authority's Wungong Urban Water Master Plan Area District Water Management Strategy (JDA, et al, 2009), the overarching district drainage strategy for the area which immediately borders the Study Area on three sides, and consistent with LWMS requirements as detailed in Better Urban Water Management (WAPC,2008).

A copy of an LWMS Checklist has been included as Appendix A to assist the Shire and DoW in review of this document. Note that this document has been previously submitted to government agencies as part of the local structure planning process, and comments previously received by government agencies have been considered in this revised version of the LWMS.

1.2 Previous Studies

1.2.1 Planning Policy 2.9 and Liveable Neighbourhoods

The LWMS has been developed in accordance with regional and local principles and objectives of Integrated Urban Water Management (IUWM).

The Western Australian Planning Commission (2004) defines IUWM (also known as total water cycle management) as promoting

> '*management of the urban water cycle as a single system in which all urban water flows are recognised as a potential resource and where the interconnectedness of water supply, stormwater, wastewater, flooding, water quality, waterways, estuaries and coastal waters is recognised*'.

IUWM should also promote water conservation measures, reuse and recycling of water and best practice in stormwater management (Western Australian Planning Commission 2004). These objectives are consistent with Liveable Neighbourhoods (Western Australian Planning Commission 2007).

1.2.2 Stormwater Management Manual for WA

The Stormwater Management Manual for Western Australia was first published by the Waters and Rivers Commission in 1998 to define and describe in practical terms Best Management Practices (BMP's) to reduce pollutant and nutrient inputs to stormwater drainage systems as well as guidelines for the incorporation of water sensitive urban design principles. A major review of the Stormwater Management Manual was undertaken by the DoW, with additional input by other State and Local Government Authorities and sectors of the urban development industry. This revised version of the Stormwater Management Manual was officially launched in 2007, though some chapters were published in 2004.

DoW's current position on Urban Stormwater Management in Western Australia is outlined in Chapter 2: Understanding the Context of the Stormwater Management Manual for Western Australia (DoW, 2007), which details the management objectives, principles, and a stormwater delivery approach for WA. Principal objectives for managing urban water in WA are stated as:

- Water Quality: To maintain or improve the surface and groundwater quality within development areas relative to pre-development conditions.
- Water Quantity: To maintain the total water cycle balance within development areas relative to the pre-development conditions.
- Water Conservation: To maximise the reuse of stormwater.
- Ecosystem Health: To retain natural drainage systems and protect ecosystem health.
- Economic Viability: To implement stormwater systems that are economically viable in the long term.
- Public Health: To minimise the public risk, including risk of injury or loss of life to the community.
- Protection of Property: To protect the built environment from flooding and waterlogging.
- Social Values: To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater.
- Development: To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles.

The then Department of Environment (now DEC/DoW) and Swan River Trust released the Decision Process for Stormwater Management in WA in 2005 to provide a decision framework for the planning and design of stormwater management systems and assist in meeting the objectives specified above. The decision process was updated by DoW in 2009. A copy of the Decision Process is contained as Appendix B with key elements summarised in Table 1.

1.2.3 Better Urban Water Management

This LWMS has been developed to be consistent with the framework and process detailed in the recently released guideline document Better Urban Water Management (WAPC, 2008). This LWMS has been prepared to an appropriate level of detail to support the Local Structure Plan for the Study Area and ensure sufficient space has been set aside in the proposed development for urban water management and that site constraints and opportunities are well understood and considered in the planning process.

An Urban Water Management Plan (UWMP) will be required to support the subdivision application in due course.

1.2.4 Peel Harvey WSUD Local Planning Policy 2006

The Peel Harvey WSUD Local Planning Policy (Peel Development Commission 2006) was developed through the Federal Governments Coastal Catchments Initiative and endorsed by the Environmental Protection Authority (EPA). It aims to assist local government to help integrate catchment management objectives with land and resource planning in urban landscapes.

The policy identifies broad policy objectives against which strategic and statutory proposals can be assessed. WSUD principles, in order of priority, are outlined below:

- Provide protection to life and property from flooding that would occur in a 100 year Average Recurrence Interval (ARI) flood event

- Manage rainfall events to minimise runoff as high in the catchment as possible. Use multiple low cost 'in-system' management measures to reduce runoff volumes and peak flows (for example, maximise infiltration from leaky pipes and stormwater pits installed above pollutant retentive material)

- Retain and restore existing elements of the natural drainage system, including waterway, wetland and groundwater features and processes, and integrate these elements into the urban landscape, possibly through a multiple use corridor

- Minimise pollutant inputs through implementation of appropriate non-structural source controls (such as town planning controls, strategic planning controls, pollution prevention procedures, education and participation programs and regulatory controls) and structural controls (that manage the quantity and quality of stormwater runoff and prevent or treat stormwater pollution)

- Maximise water use efficiency, reduce potable water demand, and maximise the re-use of water harvested from impermeable surfaces

Water quantity management principles and objectives are provided based on post-development discharges being maintained relative to predevelopment levels. Criteria are provided for both ecological protection (1 in 1 year events), and flood protection (1 in 100 year events). Water quality management principles and objectives are based on maintaining or improving water quality relative to existing conditions.

Specific water quality guidelines are provided in the document including limitations on developments where average input rates of nutrients exceed 15 kg/phosphorus/ha per annum or 150 kg/nitrogen/ha per annum.

In addition, stormwater management is stated as having to provide (as compared to a development that does not actively manage stormwater quality):

- At least 80% reduction of total suspended solids

- At least 60% reduction of total phosphorus
- At least 45% reduction of total nitrogen
- At least 70% reduction of gross pollutants

The policy is consistent with the Decision Process for Stormwater Management in WA (DoW, 2009) and is consistent with the objectives of the Environmental Protection Policy (Peel Inlet – Harvey Estuary) 1992. The policy is stated as holding no legal standing and envisages each local government in the Peel Harvey catchment will customise the model policy to suite its own specific requirements. At the time of preparing this LWMS, it is understood no customisation of this policy has been undertaken by the Shire of Serpentine Jarrahdale.

1.2.5 Wungong Urban Water District Water Management Strategy

While the Armadale Redevelopment Authority's Wungong Urban Water Master Plan, does not include the Study Area, it borders it on the north, west and eastern sides and the two areas are linked by the common drainage infrastructure of Birrega Main Drain (BMD).

A District Water Management Strategy (JDA et al, 2009) was prepared to support the Master Plan and the document provided a recommended approach for total water cycle management of the area consistent with sustainability principles. This document has been approved by DoW.

Key elements of the DWMS related to this LWMS include :

- The DWMS recommended and documented a realignment of BMD, with the focus on improving its hydraulic performance and linking it to areas of significant vegetation downstream of the LWMS area (with the latter focus due to the riparian zone of the BMD being severely degraded). This LWMS supports the realignment of the drain. In 2008, JDA undertook a detailed investigation of on behalf of SPM Project Marketing, which included hydraulic modelling of the current BMD and proposed realignment. This is discussed further in Section 1.2.6 and in relation to the proposed structure plan of the Study Area in Sections 3 and 4.2.1.

- Predevelopment monitoring data undertaken over an 18 month period, including two winters for a surface water site in the Study Area is available in the Wungong Urban Water Master Plan DWMS (JDA, et al 2009). Similarly extensive groundwater data in the area was also collected. This data, as well as a further four months of additional data collected by JDA in winter 2008 has been used to provide the baseline predevelopment monitoring data for the Study Area.

1.2.6 Assessment of Birrega Main Drain Realignment

JDA (2008) assesses the impact of a realignment of Birrega Main Drain (BMD) within the Study Area.

The report investigated the realignment of the BMD within the Study Area that is required to accommodate the future downstream realignment of BMD detailed in the approved Wungong Urban Water Masterplan (WUWMP). It is understood realignment of BMD was proposed in the WUWMP area to assist in achieving planning outcomes and in particular environmental objectives through linking the BMD to areas of significant vegetation protection, while also improving the existing hydraulic performance of the drain.

The scope of works undertaken by JDA's report included calculation of the 100 year average recurrence interval (ARI) flow of the BMD, a field investigation to inspect the condition and current alignment of the BMD, and the development of a HECRAS backwater model to assess the effect of drain realignment on hydraulic performance.

A copy of JDA (2008) is included as Appendix C.

The report was submitted to both Water Corporation and the Department of Water for assessment in advance of this LWMS to assess agency support for the relocation. A copy of the Department of Water response to the report indicating their support for the realignment is contained in Appendix D.

The Water Corporation also indicated that they are *"in principle not opposed to the possibility of realigning Birrega Drain, but it must be part of a broader accepted solution"* (Steve Hillier pers comm). These comments were provided in the context of the need for an overarching Drainage Water Management Plan (DWMP) for the wider area to be prepared by DoW, and resolution of governance issues related to level of service requirements as the drain changes from rural to urban.

Recent discussions with government agencies in March 2010 (including DoW, Shire of Serpentine Jarrahdale, Water Corporation, ARA, and Department of Planning) as part of the local structure planning process for the Study Area have indicated DoW are unlikely to undertake the preparation of a DWMP for the wider Birrega Main Drain catchment in the foreseeable future.

To this end, planning for the realignment of the Birrega Main Drain both within the Study Area and within the downstream Wungong Urban Water Precincts J and K are being undertaken based on conservative modelling and a sensitivity analysis. This will ensure sufficient space is assigned within the local structure planning process to accommodate drainage planning and the realignment.

This is considered a pragmatic approach to drainage planning for the Study Area in the ongoing absence of a DWMP for Birrega Main Drain, and consistent with the requirements of the WUWMP.

It should be noted that the inter agency governance issues of DoW and WC are considered outside the scope of this LWMS and are being handled as a separate process to this LWMS approval.

This is further discussed in Section 5.

1.3 Principles and Objectives

Summaries of key principles and objectives applicable to the LWMS for the Study Area based on the previous studies discussed in Section 1.2 are provided in Table 1.

TABLE 1: LWMS KEY PRINCIPLES AND OBJECTIVES

Key WSUD Guiding Principles		
• Facilitate implementation of sustainable best practice in urban water management • Encourage environmentally responsible development • Provide integration with planning processes and clarity for agencies involved with implementation • Facilitate adaptive management responses to the monitored outcomes of development • To minimise public risk, including risk of injury or loss of life • To maintain the total water cycle		
Category	**Principles**	**Design Objectives**
Water Supply and Conservation	• Consider all potential water sources in water supply planning • Integration of water and land use planning • Sustainable and equitable use of all water sources having consideration of the needs of all users, including community, industry and environment • Maximise the reuse of stormwater	• Minimise the use of potable water where drinking water quality is not essential, particularly ex-house use. • Residential consumption target for potable water <60 kL/person/year • Promote use of rainwater tanks for non potable supply (R20 lots) • Apply waterwise landscaping measures to open space areas to reduce irrigation demand
Groundwater Levels and Surface Water Flows	• Retain natural drainage systems and protect and/or improve ecosystem health • Protect from flooding and waterlogging • Implement economically viable stormwater systems • Post development annual discharge volume and peak flow rates to remain at predevelopment levels • Minimise change in peak winter levels due to urbanisation to protect groundwater dependent wetlands • Ensure that stormwater management recognises and maintains social, aesthetic, and cultural values	• Use ephemeral storage areas with bioretention characteristics to attenuate and infiltrate stormwater prior to discharge into Birrega Main Drain • For ecological protection, 1 in 1 year ARI volume and peak flow rates maintained at pre-development conditions • Where there are identified impacts on significant ecosystems, maintain or restore desirable environmental flows and/or hydrological cycles consistent with DoW's requirements • For flood management, manage up to the 1 in 100 year ARI event within the development area to predevelopment peak flows
Groundwater and Surface Water Quality	• Maintain or improve groundwater and surface water quality • Reduce the average annual load of stormwater pollutants discharged by development compared to if it used a traditional piped conveyance system. • Where waterways/open drains intersect the water table, minimise the discharge of pollutants from groundwater	• On site retention of 1 year 1hour rainfall event and use of bioretention systems to achieve water quality treatment objectives • Use non-structural measures to reduce applied nutrient loads.

2. PRE DEVELOPMENT ENVIRONMENT

2.1 Location and Topography

The Study Area is located in Darling Downs approximately 30km south east of the Perth Central Business District in the Shire of Serpentine Jarrahdale. The Study Area is bound to the south by Rowley Road and is approximately 12ha in size (Figure 1). It lies immediately south of the local government authority boundary between the City of Armadale and the Shire of Serpentine Jarrahdale.

Study Area topography is shown in Figure 2 based on Landgate 1m contours. The Study Area slopes gently from east to west, with the natural surface varying from 27 mAHD in the east to 26 mAHD in the west.

2.2 Climate

Perth has a Mediterranean climate with warm dry summers and cool wet winters.

The closest long term Bureau of Meteorology rainfall station is Armadale Rainfall Station, located approximately 6 km to the north-east of the Study Area. Armadale station has rainfall data from 1901 to the present. Annual rainfall data is shown in Figure 3.

Rainfall records indicate that the recent 1975-2008 average rainfall of 814 mm is approximately 54 mm less than the long term 1908-2008 annual average of 868 mm. This decrease in annual average rainfall from the mid 1970s onwards is consistent with a shift in rainfall observed over the rest of Western Australia's south-west from this time.

Rainfall in 2006 was lowest recorded in the period 1975 to 2008 (516.4 mm), and also the second lowest on record.

2.3 Geology and Soils

Figure 4 (based on the Environmental Geology Series for the Perth Metropolitan Region) shows the majority of the Study Area to have sandy clay soils. These are described as white-grey to brown clay and sand which is fine to coarse grained and subangular to rounded.

Part of the eastern area is covered with sand of eolian origin described as fine to medium-grained white to pale grey at surface and yellow at depth. This is underlain by the sandy clay to clayey sand of the Guilford Formation (Jordan 1986).

A geotechnical investigation of the proposed development was undertaken by Douglas Partners (2008) to assess the suitability of the land for the proposed development provide and provide an assessment of the permeability of the shallow soils.

The investigation found the site conditions to generally comprise topsoil (to 0.2m), medium dense to very dense sand overlying stiff to very stiff sandy clay and medium dense clayey sand.

Douglas Partners (2008) report insitu permeability ranging from 0.1-0.3 m/d based on two insitu permeability tests being performed at 0.6m depth below natural surface using the constant head method in accordance with Australian Standard AS/NZS 1547/2000. Soils at the test locations were identified as sandy clay and clayey sand.

While Douglas Partners (2008) states on-site stormwater disposal using soakwells and sumps is not considered feasible within the Study Area, imported fill is likely to provide the opportunity for some lot scale infiltration opportunities and this is reflected in the runoff rates adopted for the conceptual design of the stormwater system detailed in Section 4.2.

Lithological logs from JDA groundwater monitoring bore installation are contained in Appendix E, and were found to be consistent with broader scale environmental geology mapping and Douglas Partners (2008) investigation.

2.4 Surface Water Hydrology

2.4.1 Existing Surface Drainage

Existing surface drainage for the Study Area is shown in Figure 5.

The Water Corporation's Birrega Main Drain (BMD) flows beneath Rowley Road in a northerly direction and changes course midway through the Study Area, flowing west under Hopkinson Rd and continuing west to Tonkin Highway.

BMD is located within the Mundijong Rural Drainage District and is a rural drain maintained by the Water Corporation. It joins the Serpentine River and ultimately discharges to the Peel-Harvey Estuary. Review of existing historical maps and available aerial photographs indicate the drain in its current alignment would have been constructed after 1925 and prior to 1953.

The BMD is an unfenced steep sided excavated trapezoidal drain, without any riparian vegetation and has no designated drainage easement in the Study Area. Photo's of the existing condition of the BMD within the Study Area are contained in Appendix C.

In terms of level of service, for rural drains the Water Corporation generally apply a three day inundation rule for adjacent rural land. In this respect BMD is currently not maintained for any specific flood frequency, such as a 10 or 100 year average recurrence interval (ARI) event which would be the case for an urban drain. There is therefore no existing 100 year ARI floodplain mapping of the BMD.

Discussions with both the Water Corporation and Department of Water (DoW) have indicated no overarching drainage planning currently exists or is planned to be undertaken for BMD in the near future.

Key culvert sizes and inverts for the BMD in the vicinity of the Study Area are shown in Figure 5 based on a drain survey conducted by Whelans Survey and Mapping in April 2007. Further details of the survey are contained in Appendix C.

Culvert capacities in the vicinity of the Study Area are considered unlikely to have capacity to convey major flow events and overtopping of the roads in this area is likely.

2.4.2 Peak Flow Estimates

The catchment area for BMD is shown in Figure 6, and is approximately 350 ha to the upstream boundary of the Study Area. The catchment boundary was based on existing available topographic data and the location and flow direction of known drains.

In addition to its local catchment, Birrega Main Drain also receives flow from Wungong River. The Wungong Urban Water Master Plan District Water Management Strategy (JDA et al 2009) describes that the Wungong River is partially diverted into BMD due to the backwater effect of an existing weir on Wungong River immediately downstream of the Wungong River / BMD confluence.

JDA (2008) estimated a 100 year ARI flow for BMD of 8 m^3/s (JDA,2008) on the basis of applying a range of different standard hydrological techniques including rating the catchment against other known gauged catchments in the area, use of the Rational Method (Institution of Engineers Australia, 2001), and Water Corporation advice. JDA (2008) calculations are included in Appendix C.

The 8 m^3/s 100 year estimate equates to a rated flow of approximately 11 l/s/ha. This shows good consistency with JDA, CSIRO & GHD (2006), in which the Water Corporation provided general design advice of a 100 year rated flow for BMD in the order of 12 l/s/ha.

JDA (2008) estimated the existing capacity of the BMD at the Study Area to be approximately 2 m^3/s, which is estimated to represent a 2 year ARI flow capacity for the existing drain. Based on informal discussions with the Water Corporation it is understood applying a three day inundation rule in design typically results in a drain capacity (without overtopping) of 2-3 year ARI. The current BMD capacity based on estimated design flows is consistent with the expected design capacity based on the 3 day inundation rule, providing confidence in design flow estimates.

2.4.3 Surface Water Quality

The Wungong Urban Water DWMS (JDA et al 2009) provides water quality data for Birrega Main Drain at the Study Area. Monitoring was performed by DoW between May 2004 to November 2004. Table 2 presents the data for physical water parameters, basic and major ions, nutrients and metals. Further predevelopment surface water quality was completed in winter 2008 over a period of 4 months. Results are shown in Table 3. Summarising the results :

- Samples taken in 2004 show a range in pH of 6.99 to 8.46, with the highest readings in pH measured in September. In 2008 the pH readings varied from 5.97 to 6.52.

- Electrical conductivity (EC) readings across all surface water samples from the Study Area varied from 0.32 to 0.63 mS/cm. Using the general relationship between EC and Total Dissolved Solids (TDS) for streams in the South-West of Western Australia graphed in Mayer et al.(2005), this equates to a range of TDS between 180 to 350 mg/L.

- With respect to Total Phosphorus (TP), samples taken over the 2004 monitoring period were all less than 0.1 mg/L, the target concentration of the Water Quality Improvement Plan for the Rivers and Estuary of the Peel-Harvey System – Phosphorus Management (Environmental Protection Authority, 2008). TP concentrations only exceeded the 0.1 mg/L target in September 2008.

- Total Nitrogen (TN) N concentrations in both BMD monitoring programs do not exceed the ANZECC 2000 guideline of 1.2 mg/L for Lowland rivers in the south-west of WA.

- The ANZECC (2000) guideline concentration of aluminium for 95% protection of aquatic species in freshwater is 0.055 mg/L when the pH exceeds 6.5. The range of aluminium concentrations for surface water sampled on the Study Area ranged from 0.3 to 0.4 mg/L, exceeding these guidelines. Reasons for these high concentrations are not known however Aluminium can be released, along with iron, manganese and other heavy metals, following the disturbance of Acid Sulphate Soils. It is possible a disturbance of this soil upstream of the Study Area may have contributed to Aluminium concentrations in the BMD. In addition, Water Corporation scheme water which is discharged to Wungong River at the South West Highway (and ultimately diverted to Birrega Drain) may also contribute to the high concentrations.

- The levels of manganese and ammonia had concentrations below their respective ANZECC (2000) guidelines of 1.9 mg/L and 0.90 mg/L, respectively, for protection of 95% of aquatic life (ANZECC 2000).

- Dissolved oxygen (DO) concentrations measured by the DoW in the 2004 monitoring program were within the ANZECC(2000) guidelines for streams in the southwest of Australia, which are a lower limit of 80% DO and an upper limit of 120% DO (ANZECC 2000).

2.5 Groundwater Hydrology

2.5.1 Superficial and Leederville Aquifers

The superficial aquifer below the Study Area is the Guilford Formation, and is estimated to have a saturated thickness of approximately 25 m (Davidson 1995).

The Leederville Formation underlies the superficial formation. The Leederville Formation present beneath the study area is the Pinjar Member (Davidson 1995).

2.5.2 Average Annual Maximum Groundwater Level

To refine regional groundwater mapping contained in the Wungong Urban Water District Water Management Plan (JDA et al, 2009), JDA installed 6 groundwater monitoring bores (RH1 to RH6) in the Study Area on 9 September, 2008. All bores consist of 50mm PVC with end caps and slotted into the water table. Lithological logs are contained in Appendix E.

JDA (2009) is included as Appendix F, and details the calculation of the average annual maximum groundwater level for the Study Area as a reference point for groundwater assessment. These calculations are based on water levels recorded on 22 October, 2008 when the water tale was at its seasonal maximum.

The general direction of groundwater flow is from east to west, toward the Hopkinson Rd. The estimated average annual maximum groundwater level is shown in Figure 7, ranging between approximately 27.2 mAHD in the south-east of the Study Area and 25.8 mAHD in the north-west.

Depth to groundwater mapping is shown in Figure 6. The average annual maximum groundwater level is estimated to be at natural surface or within 0.3m of natural surface at the eastern boundary of the Study Area, ranging to 0.3-1.0 m below natural surface along the western boundary.

TABLE 2: SURFACE WATER QUALITY DATA (JDA, ET AL 2009)

Parameter	2/6/04	22/6/04	22/7/04	17/8/04	8/9/04	29/9/04	26/10/04	Samples Taken	Min	Max	Mean	Med
EC (ms/cm)	0.316	0.353	0.378	0.373	0.448	0.392	0.399	7	0.316	0.448	0.380	0.378
Salinity (ppt)	0.15	0.17	0.19	0.18	0.21	0.19	0.19	7	0.15	0.21	0.18	0.19
TSS (mg/L)	38	11	14	15	7.4	7	13	7	7	38	15.1	13
pH	7.38	6.99	7.23	8.02	8.29	8.46	7.82	7	6.99	8.46	7.74	7.82
Temp (°C)	10.56	16.58	13.39	14.8	16.9	19.6	25.1	7	10.56	25.1	16.70	16.58
CaCO3 (mg/L)	-	22	-	-	-	30	-	2	22	30	26	-
SO4 (mg/L)	-	18	-	-	-	17	-	2	17	18	17.5	-
Nox-N (mg/L)	0.011	0.16	0.26	0.21	0.16	0.13	0.03	7	0.011	0.26	0.14	0.16
NO2-N (mg/L)	-	<0.005	-	-	-	<0.01	-	2	<0.01	<0.01	<0.01	<0.01
NH3/ NH4-N (mg/L)	0.02	0.022	0.014	0.02	0.01	0.01	0.04	7	0.01	0.04	0.02	0.02
TN (mg/L)	0.3	0.47	0.5	0.56	0.42	0.31	0.45	7	0.3	0.56	0.43	0.45
PO_4-P (mg/L)	0.005	0.005	0.007	0.02	0.01	0.01	0.02	7	0.005	0.02	0.011	0.01
TP (mg/L)	0.05	0.02	0.05	0.03	0.04	0.02	0.06	7	0.02	0.06	0.04	0.04
Na (mg/L)	-	52	-	-	-	56	-	2	52	56	54	-
K (mg/L)	-	1.8	-	-	-	1.6	-	2	1.6	1.8	1.7	-
Ca (mg/L)	-	7	-	-	-	5.8	-	2	5.8	7	6.4	-
Mg (mg/L)	-	7.9	-	-	-	8.1	-	2	7.9	8.1	8	-
Al (mg/L)	-	0.3	-	-	-	0.4	-	2	0.3	0.4	0.35	-
Fe (mg/L)	-	0.25	-	-	-	0.10	-	2	0.1	0.25	0.18	-
Mn (mg/L)	-	<0.05	-	-	-	<0.05	-	2	<0.05	<0.05	<0.05	-
SiO2 (mg/L)	-	7	-	-	-	3.9	-	2				
F (mg/L)	-	0.2	-	-	-	0.2	-	2	3.9	7	5.45	-
DO (%)	91.6	89.4	93.2	99.2	118	112	115	7	0.2	0.2	0.2	-

TABLE 3: WINTER 2008 SURFACE WATER QUALITY DATA

Date	EC (mS/cm)	pH	TN (mg/L)	Nox_N (mg/L)	NH_4_N (mg/L)	TKN (mg/L)	TP (mg/L)	FRP (mg/L)	TSS (mg/L)
9/09/2008	0.61	6.32	1	0.27	<0.01	0.76	0.17	<0.003	11
22/10/2008	0.49	6.52	0.5	0.11	0.046	0.39	<0.01	<0.005	6.5
1/12/2008	0.63	5.97	0.21	0.049	0.075	0.16	<0.01	<0.005	18

2.5.3 Groundwater Quality

The Wungong Urban Water DWMS (JDA et al 2009) provides district scale water quality data for the period June 2004 to December 2004 for the area around the Study Area. ARA monitoring bore BRM11 is located only approximately 0.5km south of the Study Area and its data is presented in Table 4.

Additional monthly predevelopment monitoring of groundwater water quality was undertaken by JDA within the Study Area for the six monitoring bores RH1-RH6 for three months in winter 2008. Results of this monitoring are presented in Table 5. Summarising the results :

- Over the Study Area the pH ranged from 4.20 to 6.78. The pH of 4.20 was for bore RH6, which had pH readings below 5 for every sampling occasion. The low pH values for groundwater on the Study Area could be due to the application of agricultural and urban fertilisers.

- EC for all groundwater bore samples ranged from 0.57 to 11.84 mS/cm. Using the same EC-TDS relationship as in Section 2.4.3, the approximate range in TDS is 320 to 6630 mg/L.

- The median concentration of total nitrogen measured in samples from bores RH1 to RH6 (3.2 mg/L) was higher than the median concentration measured in samples from bore BR11 in 2004 (0.50 mg/L). All TN concentrations in groundwater samples from bores RH1 to RH6 had elevated TN levels, the maximum TN level was 11 mg/L in bore RH5 in September 2008. The elevated TN levels are likely due to the leaching of fertilisers and reflect historical land use.

- The median concentration of ammonia for was 0.11 mg/L for BRM11 samples and 0.70 mg/L for RH1 to RH6 samples. These ammonia concentrations were higher than levels measured in surface water.

- Median phosphate (PO4-P) for was less than 0.012 mg/L and the maximum PO4-P was 0.014 mg/L for all 2008 samples. These concentrations were lower than PO4-P concentration measured in BRM11 samples, which had a maximum concentration of 0.19 and a median concentration of 0.01 mg/L. Total phosphorus data for bores RH1 to RH6 gives a median value of less than 0.025 mg/L, a maximum value of 0.110 mg/L and a minimum value of less than 0.01 mg/L.

TABLE 4: GROUNDWATER QUALITY DATA (JDA, ET AL 2009)

Parameter	8/9/04	7/10/04	11/11/04	9/12/04	Samples	Min	Max	Mean	Med
EC (ms/cm)	2.95	2.76	6.11	5.99	4	2.76	6.11	4.45	4.47
pH	6.53	6.50	6.14	6.29	4	6.14	6.53	6.37	6.40
Temp (°C)	-	18.1	18.6	23.5	3	18.1	23.5	20.1	18.6
CO3 (mg/L)	<1	<1	<1	<1	4	<1	<1	<1	<1
HCO3 (mg/L)	49	130	98	82	4	49	130	90	90
CaCO3 (mg/L)	40	100	80	68	4	40	100	72	74
Cl (mg/L)	950	790	2000	2000	4	790	2000	1435	1475
CaCO3 (mg/L)	370	320	1100	1100	4	320	1100	723	735
NO3 (mg/L)	<0.1	<0.1	<0.1	0.1	4	<0.1	0.1	<0.1	<0.1
NO3_N (mg/L)	<0.05	<0.05	<0.05	<0.05	4	<0.05	<0.05	<0.05	<0.05
NO2_N (mg/L)	<0.05	<0.05	<0.05	<0.05	4	<0.05	<0.05	<0.05	<0.05
NH4_N (mg/L)	0.09	<0.05	0.13	0.14	4	0.05	0.14	0.10	0.11
TKN (mg/L)	0.77	0.55	0.4	0.35	4	0.35	0.77	0.52	0.48
Total N (mg/L)	0.8	0.6	0.4	0.4	4	0.40	0.80	0.55	0.50
PO4-P (mg/L)	<0.01	<0.01	0.19	<0.01	4	<0.01	0.19	0.06	0.01
TP (mg/L)	0.05	0.02	0.02	0.07	4	0.02	0.07	0.04	0.04
Na (mg/L)	420	400	820	930	4	400	930	643	620
K (mg/L)	22	38	33	26	4	22.0	38.0	29.8	29.5
Ca (mg/L)	61	48	180	170	4	48.0	180.0	114.8	115.5
Mg (mg/L)	53	49	4.4	170	4	4.4	170.0	69.1	51.0
Al (mg/L)	<0.005	<0.005	<0.005	<0.005	4	<0.005	<0.005	<0.005	<0.005
Fe (mg/L)	<0.01	<0.01	0.01	<0.01	4	<0.01	0.01	0.01	0.01
Mn (mg/L)	0.006	0.004	<0.001	0.001	4	<0.001	0.006	<0.003	<0.003
Si (mg/L)	4.3	5.6	9.9	30	4	4.3	30.0	12.5	7.8

TABLE 5: WINTER 2008 GROUNDWATER QUALITY DATA

Param	Monitoring Bores						Min	Max	Mean	Med
	RH1	RH2	RH3	RH4	RH5	RH6				
	9/09/08	9/09/08	9/09/08	9/09/08	9/09/08	9/09/08				
	22/10/08	22/10/08	22/10/08	22/10/08	22/10/08	22/10/08				
	1/12/08	1/12/08	1/12/08	1/12/08	1/12/08	1/12/08				
EC (mS/cm)	0.92	10.44	0.62	6.64	11.08	11.84	0.57	11.84	5.42	6.7
	0.57	8.08	0.66	1.21	8.37	6.94				
	0.87	3.13	ns	6.86	7.25	6.7				
pH	6.1	4.84	6.71	6.36	5.13	4.72	4.20	6.78	5.46	5.28
	5.64	4.56	6.5	6.78	5.04	4.55				
	5.28	4.51		6.5	5.48	4.2				
NOx_N (mg/L)	1.6	3.1	3.3	7.9	7.8	3.5	0.019	8.6	3.173	2.7
	0.019	0.87	0.062	8.6	5.2	2.3				
	0.021			3.1	1.3	2.1				
Tot N (mg/L)	3	3.4	4.3	9	11	3.4	1.3	11	4.23	3.2
	1.8	2.7	2.2	8.9	6	2.4				
	1.3			3.4	2.4	2.4				
Tot P (mg/L)	<0.01	<0.01	0.1	<0.01	<0.01	<0.01	<0.01	0.110	<0.042	<0.025
	0.03	0.02	0.11	<0.01	0.01	<0.01				
	0.04			0.01	<0.01	0.02				
PO_4-P (mg/L)	0.009	<0.003	<0.003	<0.003	<0.003	<0.003	<0.009	0.014	<0.012	<0.012
	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005				
	<0.005			<0.005	<0.005	0.014				
TKN (mg/L)	1.4	0.38	1	1.1	2.9	<0.05	<0.16	2.90	<1.12	<1.1
	1.8	1.9	2.1	0.25	0.73	0.16				
	1.3			0.28	1.2	0.33				
NH_3/NH_4-N (mg/L)	0.4	0.5	0.7	0.4	0.4	<0.01	<0.013	0.700	0.29	<0.18
	0.052	0.18	0.013	0.13	0.35	0.1				
	0.086			0.14	0.68	0.18				
TSS (mg/L)	2100	3100	2100	910	3100	1200	48	3100	1051	785
	940	660	200	48	180	77				
	1100			320	310	470				

2.6 Wetlands

There are no Resource Enhancement or Conservation Category wetlands within the Study Area.

According to "Geomorphic Wetlands of the Swan Coastal Plain" (DEC, 2009), the Study Area is located on wetland classified as multiple use palusplain (Figure 2). The multiple use classification indicates the land can be developed for urban use.

Palusplain is classified as a "seasonally waterlogged flat wetland" (Hill et al.1996).

2.7 Acid Sulphate Soils

Regional Acid Sulphate Soil (ASS) mapping is shown in Figure 8.

According to mapping published by the Western Australian Planning Commission (WAPC), the Study area is classified as having a medium to high risk of having Acid Sulphate Soils (ASS) or Potential Acid Sulphate Soils (PASS) occurring greater than three metres from the soil surface and nil risk of ASS or PASS occurring less than 3 m from surface (WAPC 2003).

ASS management during construction is discussed in Section 4.6.2.

2.8 Existing Land Use

Existing land use for the Study Area is shown in Figure 2, showing it cleared and rural.

As previously stated in Section 2.4.1, the BMD within the Study Area is an unfenced steep sided excavated trapezoidal drain, without any riparian vegetation, and has no easement.

Review of existing historical maps and available aerial photographs indicate the drain in its current alignment would have been constructed after 1925 and prior to 1953.

2.9 Water Resources

The Study Area is in the Jarrahdale Groundwater Sub-Area. Recent discussions with the Department of Water had indicated the Jarrahdale sub-area superficial aquifer is currently 73% allocated and the remaining available allocation is 430 000 kL/yr.

3. PROPOSED DEVELOPMENT

The proposed Local Structure Plan for the Study Area (dated 10January 2012) is shown in Figure 9. The Study Area is currently zoned as urban under the Metropolitan Region Scheme (DPI 2007).

The structure plan shows that land use in the proposed development will consist of:

- A mix of residential lots zoned R20, R30, R40.
- Public Open Space (POS)
- Roads

Key elements of the Local Structure Plan relating to urban water management include:

- Relocation and rehabilitation of the existing degraded Birrega Main Drain as a living stream within a multiple use POS corridor.
- Sections of POS areas to be used for stormwater quality treatment, detention and retention.
- Higher density urban residential zonings to reduce landscape nutrient input at a residential scale.

4. LOCAL WATER MANAGEMENT STRATEGY

The following chapter details the proposed Local Water Management Strategy for the Study Area. It includes discussions regarding water use and conservation, and details key elements of groundwater, surface water and water quality management with respect to demonstrated best management practice in water sensitive urban design.

Issues related to implementation are discussed in Chapter 5.

4.1 Water Use & Sustainability Initiatives

4.1.1 Water Sources

It is proposed to use groundwater from the Superficial Aquifer to irrigate Public Open Space (POS) areas.

Based on an irrigation requirement of 7500 kl/ha/yr and POS area of approximately 1.1ha (inclusive of the Birrega Main Drain corridor) the POS irrigation demand is likely to be in the order of 8250 kl/yr. This volume is minor in comparison to available groundwater allocation in this area (Section 2.9).

Licences to drill production bores or to abstract groundwater for this purpose will be submitted to the Department of Water for consideration in due course.

Scheme water is proposed to be used for domestic household supply. A development scale water reuse scheme is not planned for the Study Area.

4.1.2 Water Conservation

Development of the Study Area will lead to an increased demand for water for new residents as well as irrigation of public open spaces. Water conservation measures will be implemented to reduce scheme water consumption within the development will be consistent with Water Corporation's "Waterwise" land development criteria, and include:

- Use of higher density residential zoning (R20-R40) and smaller lots to reduce garden (ex house) use of water.
- Promotion of use of waterwise practices including water efficient fixtures and fitting (taps, showerheads, toilets and appliances, rainwater tanks for R20 lots, waterwise landscaping)
- Use of drought tolerant native plants in POS areas
- Use of groundwater bores for irrigation of POS and common areas
- Maximising on site retention of stormwater

Specific measures to achieve water conservation and will be detailed in the UWMP and incorporated within the development of detailed landscape plans. These plans will be integrated with those of the adjacent WUWMP area.

4.1.3 Non Potable Water Supply & Water Balance

A water balance at the LWMS stage is generally requested to support the identification of excess water generated by the development for potential use as a non potable water supply scheme.

Use of local groundwater or alternative non potable water supply schemes for household use is not currently considered viable for the Study Area.

Available local groundwater for large scale supply is limited and alternative non potable supply options such as stormwater or wastewater reuse are unlikely to be viable at present, largely due to regulatory constraints, within the current development timeframe. While ARA are investigating the feasibility of non potable options for the adjacent WUW Masterplan Area, the timing for completion of these studies are well outside the development timeframe of the Study Area.

Given the allocation of existing groundwater resources, the water source planning strategy for the Study Area is for use of scheme water for domestic use (both in and ex house) and use of groundwater bores for irrigation of POS areas. Rainwater tanks will be promoted on R20 Lots to assist in reducing excess stormwater generation and minimise scheme water importation.

Sizing of rainwater tanks for R20 lots and further details of POS supplies will be provided at UWMP stage, commensurate with requirements of building design. Consistent with UWMP guidelines a quantitative water balance at lot scale will be conducted at UWMP stage to demonstrate overall compliance with water use targets (Table 1).

4.2 Surface Water Management

4.2.1 Review of Emerson Stewart (2010)

Emerson Stewart (2010) details an analysis of the proposed realignment of the Birrega Main Drain within the Wungong Urban Water Precinct K structure plan area located immediately downstream of the Study Area. JDA understands the report has been accepted by government agencies with Birrega Main Drain to be realigned immediately downstream of the Study Area within a 60m living stream corridor, consistent with the Wungong Urban Water Precinct K structure planning shown in Figure 3. It should be noted that the 60m corridor provided within the WUW Masterplan was largely established for planning outcomes and environmental purposes rather than flood conveyance, and a significantly lesser width is required for flood conveyance requirements.

A recommendation of Emerson Stewart (2010) was that approximately 13,500 m^3 of flood storage is currently provided within the Study Area to attenuate flows downstream of Hopkinson Rd and that this storage must be kept post development and that the existing culvert capacity and Hopkinson Rd inverts must similarly be maintained.

This recommendation is provided in the context of the potential removal of floodplain storage within the Study Area resulting in increased flood levels upstream and/or increased culvert capacity resulting in increased flows to the downstream environment.

This estimate of floodplain storage in Emerson Stewart (2010) was based on an estimated 100 year ARI flow rate of approximately 6 m^3/s and 100 year flood level of 26.4 mAHD within the Study Area based on anecdotal evidence of observed flood levels during the July 1987 flood event. A flood level upstream of Rowley Rd of 27.3 mAHD was provided in Emerson Stewart (2010).

Note that analysis in this LWMS report has conservatively been based on adopting a 8 m^3/s flow rate rather than the 6 m^3/s adopted in Emerson Stewart (2010).

Emerson Stewart (2010) mapping is shown in Appendix G in relation to JDA analysis of this same data.

Summarising the results of the JDA analysis :

a) JDA do not believe it to have been physically possible for flood levels upstream of the Study Area to reach 27.3mAHD. Figure G1 shows this would have resulted in a waterfall over an extended section of Rowley Rd at depth 0.3 m or above and in excess of 1.0 m in some sections.

b) Given Water Corporation evidence that Hopkinson Rd remained dry during the 1987 flood event (Emerson Stewart, 2010), flood levels within the Study Area could not have exceeded a maximum of 26.2 mAHD. This is clearly shown in Figure G2 in relation to road levels and based on detailed analysis of LiDAR data. This significantly reduces the estimates of floodplain storage provided within the Study Area from 13,100 m^3 at 26.4 mAHD (Emerson Stewart estimate was 13,500 m^3 at this elevation) to 4,900 m^3 at 26.2 mAHD. Tabulated floodplain storage volumes at various elevations are shown in Table 6.

On this basis JDA consider the floodplain storage provided in Emerson Stewart (2010) to be conservative, and while this may have been appropriate for analysis purposes for consideration of Precinct K, is not considered analysed to sufficient detail for application for the Study Area.

JDA consider that based on the analysis conducted for the LWMS, based on a 100 year flow rate of 6 m^3/s as per the Emerson Stewart (2010) report a floodplain storage of 4,900 m^3 at 26.2 mAHD is required. A conservative assumption would be the adoption of a 26.3 mAHD (8500 m^3) which would consider uncertainties in flow and Hopkinson Rd effectively acting as a spillway above this level.

It should be noted that the above estimates are inclusive of direct runoff from the Study Area itself hence the regional flood storage component would be less. JDA estimate that for the 6-7 July 1987 event, based on a conservative 35% runoff from the local catchment and a total of 108 mm of rainfall, local runoff from the Study Area itself would have been in the order of 4000 m^3.

A conservative regional flood storage flood estimate of 4500 m^3 for the Study Area is therefore proposed for design considering local Study Area runoff and a 26.3 mAHD Hopkinson Rd spillway level.

For design purposes, consistent with Water Corporation requirements it is recommended the existing road elevations of Hopkinson and Rowley Rd be maintained and culvert capacities into and out of the Study Area similarly be kept.

Discussions with Officers at the City of Armadale and Shire of Serpentine-Jarrahdale suggest that there are currently no plans for upgrades to Hopkinson Rd (Doug Martin, City of Armadale, Craig Wansbrough, Shire of Serpentine-Jarrahdale).

At present four culverts discharge from the Study Area across Hopkinson Rd including a 1.2 x 0.5m box culvert and three circular culverts (900 mm, 375mm, and 400 mm dia). These may be consolidated to a single culvert of equivalent capacity at UWMP stage. This will be negotiated with Water Corporation in due course.

Opportunities for alternative hydraulic structures which would result in no overtopping of Hopkinson Rd yet maintain existing design flows to downstream areas will also be considered at UWMP stage. This may ultimately result in a reduced 100 year flood level at this location.

TABLE 6: EXISTING STUDY AREA FLOODPLAIN STORAGE

Elevation (mAHD)	Regional & Local Floodplain Storage within Lots 1&2 Rowley Rd (m^3)
26.0	1200
26.1	2600
26.2	4900
26.3	8500
26.4	13100

4.2.2 Regional Flood Management

The proposed realignment of the BMD presented in this report is consistent with the WUW Master Plan and its DWMS and effectively represents the first stage of its proposed realignment from the Study Area to Tonkin Highway.

JDA (2008) attached as Appendix C, details investigations of the hydraulic implications of staged construction of the realignment of BMD and found both filling of the Study Area for development and a staged realignment of the drain could occur without adversely affecting flood levels either upstream or downstream of the Study Area. The investigations found future realignment of the BMD downstream of the Study Area would provide opportunities for an overall improved hydraulic performance of the BMD system.

JDA understand urban development of the WUW Master Plan Precinct K immediately west of the Study Area is currently being progressed by Peet and Co and preparation of a LWMS for this area is nearing completion. The local structure plan for Precinct K accommodates a realignment of the BMD consistent with that proposed in the DWMS (JDA, et al 2008).

Flood levels for BMD for the 100 year ARI storm event are detailed in Appendix C.

The re-aligned drain will be approximately dimensioned as shown in Figure 13 with a similar invert to the existing drain and 1:6 side slopes. A setback buffer of 30m will be provided to allow for the construction of the shallow drain and sloping banks, which will provide sufficient floodplain storage to match existing regional floodplain storage requirements (as defined in Section 4.2.1).

A 30m setback is consistent with the BMD realignment set back buffer within Precinct K on the northern side of the drain. Any future development on the southern side of the southern side of Rowley Rd would similarly be required to provided sufficient floodplain storage if filling of the area is proposed.

Minimum habitable floor level for areas adjacent to BMD will be set 0.5 m above the 100 Year ARI flood level, consistent with DoW flood protection requirements.

4.2.3 Local Flood Management

Local stormwater management is proposed to be undertaken consistent with water sensitive design practices and meet key objectives and criteria as detailed in Table 1.

The local stormwater management system will consist of a series of pipes and subsoil drainage, living streams and bioretention areas, and ephemeral water storage areas to attenuate and infiltrate peak surface water flows, and provide water quality treatment for the proposed development prior to discharge from the Study Area.

The stormwater drainage system will be designed using a major/minor approach. The minor drainage system is defined as the system of underground pipes, kerbs, gutters etc. designed to carry runoff generated by low frequency ARI storms, typically less than 5 year ARI. The major drainage system is defined as the arrangement of roads, drainage reserves, attenuation/infiltration areas and open space planned to provide safe passage of stormwater runoff from extreme events which exceeds the capacity of the minor system.

Stormwater runoff generated by the impervious areas of the road reserve will be collected in gully or side entry pits and then flow to a local piped drainage system. Attenuation of flow will then be achieved through provision of detention storage areas in POS areas.

Consistent with principles and objectives discussed in Section 1.3, stormwater will be required to maintain 1 in 1 year ARI event post development discharge volumes and peak flow rates at predevelopment conditions. This will be achieved via bioretention areas located within road reserves (where possible) and POS areas. Opportunities to maximise infiltration opportunities within the confines of the site constraints will be considered and detailed at UWMP stage.

Detention/retention areas will generally be designed to attenuate runoff for storm events up to 100 year ARI, with basin outflow designed to not exceed predevelopment (existing) levels. The minimum building floor levels will comply with DoW and Shire of Serpentine Jarrahdale requirements for a 0.5m clearance above the estimated 100 year ARI flood level.

All stormwater detention areas are proposed to be ephemeral and no open water body lakes are proposed. This approach is consistent with the DoWs current policy on the use of constructed lakes for stormwater management.

4.2.4 Conceptual Stormwater System Design

XP-Storm modelling was performed for the Study Area to determine flood storage requirements for local flood management post development and provide a framework for the stormwater management system. Modelling was based on the proposed land use plan shown in Figure 9.

Stormwater detention areas were designed to contain runoff from 1, 5 and 100 year ARI storm event, with basin discharges for both ARIs designed not to exceed estimated pre-development (existing) levels based on DoW requirements. Design flows are detailed in Table 7. Basin outlets for this modelling were set at a Controlled Groundwater Level (CGL) defined as 300 mm above the AAMGL (previously calculated in Section 2.5.2) based on Shire of Serpentine Jarrahdale advice. No lowering of groundwater below the CGL is proposed.

Conceptual detention locations were determined based on topographic contours, depth to groundwater mapping, and POS areas specified in the Local Structure Plan. Detention area flood rises were designed to be typically in the order of 1m, with consideration of the flat topography of the Study Area and minimise fill requirements over the site. Side slopes of 1 in 6 (v: h) have been assumed above the CGL for modelling purposes. Internal catchment boundaries were generally determined on the basis of existing topographic catchment divides, with consideration of future land use and POS locations.

With respect to BMD a linear POS corridor of 30m has been allowed for to provide integration with landscaped areas of the downstream Wungong Urban Water Masterplan Area. Side slopes of 1:6 have been used for modelling of the realigned BMD, with the inverts of the drain maintained at existing levels.

The total provided floodplain storage within the BMD within this 30m corridor is estimated as approximately 5000 m^3 (based on ~25 m^3/linear metre of BMD) which is in excess of estimated predevelopment regional floodplain storage (Section 4.2.1).

The design storms modelled by XP-STORM were calculated internally by the model with reference to the methodology in Australian Rainfall & Runoff (AR&R) (Institution of Engineers, Australia 2000). The rainfall temporal pattern was assumed to be spatially uniform across the catchment. Storm durations modelled ranged from 10 minutes to 72 hours with critical durations for the basins ranging from 1 day to 3 days.

The following runoff coefficients for various land uses were used for modelling based on discussions with the Shire of Serpentine Jarrahdale :

• Residential Lots (size >350 m^2)	15% (soakwells)
• Residential Lots (size <350 m^2)	75% (direct connection)
• Group Housing	15% (on-site detention/retention required)
• POS	10%
• Swales/Drainage Area	100%
• Internal Subdivision Road & Road Reserve	90% (internal subdivision)
• External Major Road & Road Reserves	75% (future swales/on-site retention required)

The proposed local flood management system for the Study Area is shown in Figure 10 and Table 7 detailing areas required in POS for flood management purposes. Figures 11 and 12 show XP-STORM hydrographs for flood storage areas and key water levels for design purposes at UWMP stage. Figures 13 and 14 show key cross sections and long sections.

Referring to Figure 10 and Table 7:

- For Catchment A basin the AAMGL is 26.3 mAHD. The basin invert and pipe outlet invert are both at 26.6 mAHD;
- For Catchment B basin the AAMGL is 26.1 mAHD. The basin invert and pipe outlet to BMD invert are both at 26.4 mAHD.

The total area required for detention storage for the 100 year ARI event is approximately 2% of the total Study Area (excluding BMD requirements).

Storm volumes for the 1 hour 1 year ARI event (calculated as 50% times equivalent impervious area times 16 mm) are also provided in Table 7 to provide a guide for storage requirements for water quality treatment of this event within each catchment. These volumes and areas will be refined at UWMP scale and are considered likely to be ultimately smaller than those shown in Table 7. Opportunities for distributed bioretention pockets within local road reserves will be identified at UWMP stage with more detailed design. Note that storage shapes shown in Figure 10 are indicative only for determination of area requirements and representation of storage areas required in relation to POS areas allocated in the structure plan.

The final detention area configuration (side slopes etc) and locations will be documented in the UWMP and will be dependent on final earthworks, drainage, and road design levels for the development. Minor changes (refinements) in catchment areas shown in this report are therefore considered likely to occur as detailed design proceeds. Stormwater modelling and runoff coefficients used in this LWMS will require further refinement during the UWMP stage as areas of subsoil drainage and lot connections are more accurately defined.

The detailed basin design which will occur at UWMP stage will include the design of such features as different base invert levels within basins to accommodate various ARI storm events and ensure useable POS areas for areas which are set aside as major flood storage areas (as opposed to frequently inundated areas).

Opportunities for local infiltration and further distributed detention storage which may arise during detailed design for the development may also result in smaller bottom of catchment storages being required.

Discussion regarding the system compliance with DoW requirements is contained in Section 4.7. Landscaping design for POS areas will be undertaken in conjunction with detailed design and preparation of the Urban Water Management Plan and submitted for agency approval in due course. Typical concepts will be based around small ephemeral vegetated wetland areas for frequently occurring events with larger events flooding grassed POS areas. Swales will be established as bioretention systems.

4.3 Groundwater Management

The implementation of a controlled groundwater level (CGL) within a development area is dependent on a range of local site conditions including the soil type and its relationship to groundwater levels (regional and/or perched), the presence of ASS, the existence of pollutants or nutrients within groundwater, and the need to protect wetlands and receiving environments.

This LWMS proposes establishing a CGL at the AAMGL level established in Section 2.5.2. Minimum separation between building floor levels for development and groundwater will be achieved by filling of house pads and/or installation of subsoil drainage within road reserves to limit groundwater to the CGL. Subsoil drainage will be required over the whole of the Study Area and will be installed at the CGL. A cross section schematic of showing the impact of subsoil drainage installed at the CGL is shown in Figure 15.

Subsoil drains will be connected to stormwater drains at stormwater inlet manhole pits (either side entry pits or grated pits). As such stormwater pipes will discharge both stormwater and subsoil drainage to the bioretention areas of the swales.

Subsoil drainage will be treated prior to discharge to the receiving environment. Treatment will occur within bioretention areas with the design of the bioretention area specified in the UWMP consistent with local government requirements and WA Stormwater Management Manual (DoW, 2007) and FAWB (2008) guidelines.

This will be achieved by installing subsoil drainage beneath the bioretention areas below AAMGL to allow vertical movement of subsoil drainage through the filter medium.

This LWMS establishes criteria and the general approach for setting finished lot levels. Finished lot levels and fill requirements are a detailed design issue and will addressed during preparation of the UWMP and submitted for Council approval at this stage.

Minimum clearance of floor levels will be maintained at 1.2m above the CGL. As discussed in Section 2.3, Douglas Partners (2008) states on-site stormwater disposal using soakwells and sumps is not considered feasible within the Study Area. Notwithstanding this finding, JDA consider imported fill is likely to provide the opportunity for some lot scale infiltration. Likely areas of soakwell and lot connections area shown in Figure 10. For lots in excess of 350 m^2 in size, where lot connections are proposed, opportunities for on site detention and retention will be examined at UWMP stage.

On lots >350 m^2, a commitment is made by the Developer to detaining the 1yr ARI 1hr duration storm in either soakwells or rainwater tanks. At UWMP stage, this commitment will be included in a detailed area plan (DAP) and as such mandated by the Council through the Building Approvals process.

Details submitted for Council and DoW consideration at this time will include calculations detailing fill levels relative to mounding between subsoil drains for various ARI storm events to demonstrate compliance of the design to required standards. Plans showing proposed finished lots levels relative to design constraints will be provided in the UWMP to enable compliance with design criteria to be assessed.

TABLE 7: XP-STORM MODELLING RESULTS

Post-Development Catchment	**A**	**B**
Catchment Area (ha)	7.73	4.56
Pre Development		
100 Year Flow Estimate (m^3/s) based on 11 l/s/ha (Section 2.4.2)	0.08	0.05
5 Year Flow Estimate (m^3/s) based on calibrated XP-Storm Model (estimate of 6.5 l/s/ha)	0.05	0.03
Catchment Data		
POS (ha)	0.24	0.29
Residential - Connected (ha)	0.72	1.38
Residential – Not Connected (ha)	4.0	1.32
Road & Road Reserve (ha)	2.77	1.56
Catchment Slope	0.005	0.005
Equivalent Impervious Area (ha)	3.53	2.58
Storage Data		
Type	Ephemeral Basin	Ephemeral Basin
Base Area (ha)	0.06	0.05
Side Slopes (v:h)	1:6	1:6
Storage Outlet Level (mAHD)	26.6	26.4
Nominal Pipe Outlet Dia (mm) [3]	220	150
1 Year ARI		
1 Year 1 Hour Storm Volume (m^3)	280	205
5 Year ARI [5]		
Top Water Level Area (ha)	0.10	0.08
Flood Storage (m^3)$_1$	475	320
Flood Rise (m)$_2$	0.60	0.60
Peak Outflow (m^3/s)	0.05	0.05
Critical Duration (hrs)	48	48
100 Year ARI [4]		
Top Water Level Area (ha)	0.13	0.11
Flood Storage (m^3)$_1$	940	700
Flood Rise (m)$_2$	1.00	0.90
Peak Outflow (m^3/s)	0.05	0.05
Critical Duration (hrs)	3	24

1. Flood storage above basin base.
2. Flood rise refers to Top Water Level minus basin base.
3. Pipe diameters shown should be considered nominal only for modelling purposes. Actual size to be determined in UWMP stage based on commercially available sizes. Orifice plates or equivalent may be necessary to limit flows to allowable discharges
4. Post development tailwater condition of 26.3 mAHD assumed at Hopkinson Rd (based on existing road level) and conservative 100 year flow of 8 m^3/s in Birrega Main Drain.
5. Tailwater condition of 25.6 mAHD assumed at Hopkinson Rd and 5 year flow of 3 m^3/s in Birrega Main Drain
6. Hopkinson Rd hydraulic capacity to be maintained post development. Equivalent culvert size and structure to existing capacity be determined at UWMP stage (refer Section 4.2.1).

4.4 Wetland Management

As previously discussed in Section 2.6, there are no CCW's or EPP lakes located within the Study Area. No specific strategy for protection of wetlands is therefore required for this development.

4.5 Water Quality Management

With respect to water quality management the LWMS proposes the use of a treatment train approach including source control techniques. The proposed water quality management approach for the Study Area includes:

- **Non Structural Controls**
  Planning practices (POS locations and configuration)
  Construction practices (construction management, soil amendment, use of native plantings)
  Maintenance practices (street sweeping, stormwater system, POS areas, fertiliser management)
  Educational and participatory practices (capacity building programs, community education)
- **Structural Controls**
  Detention and treatment of frequent events in bioretention systems in POS and road reserves
  Rehabilitation of existing trapezoidal open drain into a living stream within POS corridor
  Creation of ephemeral retention/detention areas within POS areas
  GPT's at outlets
- **Monitoring**
  Establishment of pre and post development monitoring network
  Annual reporting, including ongoing assessment of BMP's performance and suitability to provide ongoing guidance and review for future WSUD planning within the Study Area.

With respect to criteria for water quality, PDC(2006) criteria are to be adopted in addition to a more general principle of improving water quality in comparison to existing water quality.

To achieve its water quality objectives, the LWMS focuses on implementing current known best management practice as detailed in the DoW's Stormwater Management Manual for Western Australia (2007) and the Decision Process for Stormwater Management in Western Australia. (DoW, 2009), with an emphasis on nutrient input source control, and maintaining and treating 1 in 1 year ARI post development discharge volumes and peak flow rates at pre development levels.

Establishment of bioretention systems for the development area will be detailed in the UWMP for water quality treatment purposes consistent with DoW's current approach to stormwater management.

4.5.1 Post Development Nutrient Input

NiDSS is a tool developed by JDA Consultant Hydrologists to assist in landuse management planning, and allow quantitative estimation of nutrient input rates and the potential reduction in nutrient input (including costings) for various combinations of water sensitive urban design (WSUD) water quality management measures. NiDSS focuses on the adoption of an integrated catchment approach to water quality management, including measures to minimise nutrient inputs at source, and provides a logical framework for the evaluation of the effectiveness of various best management practices for nutrient input management.

It calculates the total expected nutrient input for a particular development proposal based on aggregating individual nutrient inputs from different land uses (lots, POS, road reserves, conservation areas) prior to implementation of stormwater management measures. The impact of individual source and in-transit controls on nutrient input can then be determined by either turning on/off individual controls or varying the effectiveness of these measures. The results present information on :

- estimates of total phosphorus (TP) and total nitrogen (TN) application to an area;
- estimates of reductions due to source control measures (education, street sweeping);
- estimates of reductions due to in-transit controls (Gross Pollutant Traps, WPCP's); and
- estimates of the cost of removal (in PV terms) for a selected WSUD program.

NiDSS was applied to the Study Area to model existing land use and the proposed Structure Plan land use. Nutrient application rates were adopted from the Southern River Urban Water Management Strategy (JDA, 2002), which based application rates on a nutrient input survey conducted by JDA of medium density residential areas, and on previous work of Gerritse *et al.* (1991,1992) at CSIRO on rural residential lots.

Results of NiDSS modelling are presented in Appendix H. Summarising modelling results:

- Pre-development (existing) rural land use is estimated to have nutrient input loadings of greater than 20 kg/ha/yr for TP and 60 kg/ha/yr of TN. These estimates are based on assuming typical rural land use nutrient application rates for pasture, and do not reflect higher application rates for more nutrient intensive land use practices which may have historically occurred within the Study Area.

- With the proposed urban land use and assuming no WSUD, the Study Area is estimated to have nutrient input loadings of 12 kg/ha/yr for TP and 68 kg/ha/yr of TN.

- With implementation of a typical WSUD nutrient input reduction program including:
  1. Gross Pollutant Traps,
  2. Street Sweeping,
  3. Education Campaigns (targeting fertiliser application rates),
  4. Focus on Native Plantings for Residential and POS Areas (and use of P free fertilisers),

  it is estimated nutrient input loadings can be lowered to below current application levels under existing land use. An example program is shown in Appendix H. This indicates a reduction in application rates to 9 kg/ha/yr for TP and 52 kg/ha/yr of TN, which are less than to PDC(2006) requirements.

4.5.2 Assessment of Proposed Structural BMPs to Design Criteria

Table 8 details a summary from DoWs Stormwater Management Manual for Western Australia (2007) of expected pollutant removal efficiencies for vegetated swales and detention/retention systems in relation to the PDC (2006) water quality design criteria previously discussed in Section 1.2.4.

Expected nutrient input reduction via non structural measures calculated in Section 4.5.1 are also reported in Table 8.

While DoW (2007) does not provide expected pollutant removal efficiencies for all BMPs, application of a treatment train approach using a combination of non structural and structural measures detailed in Section 4.5 will therefore clearly achieve the design objectives for water quality.

Specific details on the location, scale of application, and responsibilities for individual BMPs will be addressed during development of the Urban Water Management Plan (UWMP).

TABLE 8 : BMP WATER QUALITY PERFORMANCE IN RELATION TO DESIGN CRITERIA

Parameter	**Design Criteria via PDC(2006)** (required removal as compared to a development with no WSUD)	**Non Structural Controls** (refer Section 4.5.1) Nutrient Input Reduction	**Structural Controls** Nutrient Output Reduction [1]	
			Vegetated Swales	**Detention/ Retention Measures**
Total Suspended Solids	80%	-	60-80%	65-99%
Total Phosphorus	60%	30%	30-50%	40-80%
Total Nitrogen	45%	24%	25-40%	50-70%
Gross Pollutants	70%	-	-	>90%

1. Typical Performance Efficiencies via DoW (2007)

4.6 Construction Management

4.6.1 Dewatering

Dewatering of the superficial aquifer will be required for some elements of development construction. As the volume of dewatering will be small compared to aquifer storage and this is infiltrated back into the superficial aquifer, the impact upon the aquifer will be minimal.

Drawdown will occur at the dewatering site, and mounding where the water is infiltrated. It should be noted that there will be zero net loss of groundwater, as all water abstracted will be infiltrated (except for minor losses to evaporation).

Prior to the commencement of any dewatering, construction contractors will be required to apply for and obtain from DoW a ‘Licence to Take Water’. All dewatering will be carried out in accordance with the conditions of this licence.

Where possible, construction will be timed to minimise impacts on groundwater and any dewatering requirements.

4.6.2 Acid Sulphate Soils

As previously discussed in Section 2.7, there is a possibility for ASS to be present on the Study Area.

All assessment and management of ASS will be conducted in accordance with the Acid Sulfate Soil Guideline Series Identification and Investigation of Acid Sulfate Soils (DoE, 2004a), including a Preliminary Site Assessment (PSA) involving a targeted soil and groundwater sampling and analysis program, .detailed site assessment (if required), and ultimately and an ASS Management Plan if ASS is to be impacted.

During construction, appropriate handling methods will need to be employed by the construction contractor to manage any potential acid sulphate soils. Handling should be in accordance with the Acid Sulfate Soils Guidelines Series Treatment and Management of Disturbed Acid Sulphate Soils (DoE, 2003). These guidelines specify holding times and specific methods for treatment of such soils.

To confirm the status of soils, the site engineer or scientist will regularly inspect the excavations and spoil, and ensure such soils where encountered are appropriately tested and managed before reuse or disposal off-site.

4.7 Water Management Strategy Summary

Table 9 provides an overall summary of key elements of the proposed water management strategy for the Study Area, with an assessment of the strategy in relation to DoW (2007) principle objectives for stormwater management in Western Australia (Section 1.2.4).

TABLE 9: SUMMARY OF PROPOSED LOCAL WATER MANAGEMENT STRATEGY

Principle	Key LWMS Elements
Water Quantity To maintain the total water cycle balance within development areas relative to the pre-development conditions.	• Maintain flow paths for existing catchments • Maintain 1 in 1 year ARI event post development discharge volume and peak flow rates relative to predevelopment conditions • Maintain 5 and 100 year ARI peak flows from the Study Area to at or below current discharge levels. • Stormwater detention area outlets set at defined CGL (AAMGL+300mm). • Maximise infiltration opportunities.
Water Quality To maintain or improve the surface and groundwater quality within development areas relative to pre-development conditions.	• Change in land use and WSUD to reduce nutrient input in the Study Area. • Maintain 1 in 1 year ARI event post development discharge volume and peak flow rates relative to predevelopment conditions • Relocation and rehabilitation of Birrega Main Drain as a living stream • Use of treatment train approach to stormwater management • Application of source controls – including street sweeping, education to reduce nutrient application, native plantings, passive POS areas, lot soakwells. • Application of structural controls – retention/detention areas, gross pollutant trapping devices, living stream. • Post development monitoring program and performance review process
Water Conservation To maximise the reuse of stormwater	• Implement water efficiency and demand management measures in and ex-house. • Use of native plantings in POS areas and passive POS areas to minimise irrigation
Ecosystem Health To retain natural drainage systems and protect ecosystem health	• Relocation and rehabilitation of Birrega Main Drain as a living stream • Relocation of Birrega to enable habitat and vegetation linkage downstream of the Study Area • Gross pollutant trapping devices to be installed on outlets
Economic Viability To implement stormwater systems that are economically viable in the long term	• Use of proven structural WSUD technology • Use of source control techniques to minimise cost of nutrient management (Appendix J)
Public Health To minimise the public risk, including risk of injury or loss of life to the community	• Design in accordance with relevant design standards, best management practices, council regulations and government agency requirements.
Protection of Property To protect the built environment from flooding and waterlogging	• Provision of 100 year ARI flood protection for Study Area • Protection of downstream areas by restricting stormwater discharge to existing levels for storm events up to 100 year ARI. • Subsoil drainage to be implemented to control seasonal groundwater rise to the defined CGL.
Social Values To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater	• Relocation and rehabilitation of Birrega Main Drain • Integration of drainage and POS functions
Development To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles.	• Urban water management in accordance with Better Urban Water Management (WAPC, 2008) • Development of the LWMS in accordance with government agency guidelines and best management practice recommendations. • Use outcomes of continuing pre development and post development monitoring programs to help guide future water management.

5. IMPLEMENTATION

5.1 Roles and Responsibilities

Table 10 details the roles and responsibilities to undertake the implementation plan. Further detail is provided regarding each deliverable in the section outlined in Table 10 below.

Governance issues related to the change in level of service requirements of the BMD from a rural drain to urban with development of the Study Area, are not unique to this project and represent a wider strategic and staging issue currently being considered by various government agencies where urban development is occurring in previously rural drainage districts.

These strategic inter agency drainage governance issues of DoW, WC and local authority are considered outside the scope of this LWMS. Governance of the BMD post development will be resolved by the relevant government agencies prior to the development of the UWMP.

Notwithstanding the above, the Shire of Serpentine Jarrahdale have indicated (Craig Wansborough, pers comm.), that they would be prepared to accept the responsibility for maintaining the realigned drain within the Study Area post development. Any written Deed of Agreement between the Water Corporation and Shire will be undertaken as a separate process which would be undertaken parallel to the UWMP phase of the project.

TABLE 10: IMPLEMENTATION RESPONSIBILITIES

IMPLEMENTATION		RESPONSIBILITY	
LWMS Section	**Action**	**Developer**	**Shire of Serpentine Jarrahdale**
5.2	Preparation of an Urban Water Management Plan to support subdivision application	✓	
5.2	Realignment of Birrega Main Drain (BMD)	✓	
5.2	Landscaping of POS and BMD	✓	
5.2	Community Education Campaign	✓	
5.3	Construction of Stormwater System	✓	
5.3	Stormwater System Operation and Maintenance	✓ (until handover)	✓ (after handover)
5.4	Monitoring program – 2 years post development	✓	

5.2 Subdivision Application Process

A UWMP for the Study Area will be submitted by the developer to the Department of Water and the Shire of Serpentine Jarrahdale to support subdivision application. The UWMP will address:

1. Agreed/approved measures to achieve water conservation and efficiencies of use including sources of water for non-potable uses and detailed designs, controls, management and operation of any proposed system (including provision of POS and BMD realignment and rehabilitation landscape plans) ;

2. Management of groundwater levels, including maintenance of ecosystem health and any proposed dewatering, (including the location of any proposed subsoil drainage) ;

3. Detailed stormwater management design including the size, location and design of public open space areas, integrating major and minor flood management capability, landscape plans as related to stormwater function, specific details of local geotechnical investigations and their impact on stormwater design ;

4. Specific structural and non-structural BMPs and treatment trains to be implemented including their function, location, maintenance requirements, expected performance and agreed ongoing management arrangements (including details of community education programs);

5. Measures to achieve protection of waterways, remnant vegetation and ecological linkages;

6. Adequacy of buffers proposed in the Local Structure Plan having consideration of any controlled groundwater level (CGL) proposed;

7. Management of subdivisional works (to ensure no impact on regional conservation areas, maintenance of any installed BMPs and management of any dewatering and soil/sediment, including dust);

8. Management of disease vector and nuisance insects such as mosquitoes and midges;

9. Implementation plan including monitoring program, roles, responsibilities, funding and maintenance arrangements. Contingency plans should also be indicated where necessary.

As previously discussed in Sections 2.4 and 2.5, the Wungong Urban Water DWMS (JDA et al 2009) provided over 18 months of district scale monitoring data, which had been supplemented with additional monitoring data for winter 2008 to inform the development of this LWMS. The requirement for any additional monitoring data from the Study Area to inform the detailed design process will be made at UWMP stage in consultation with DoW.

5.3 Stormwater System Operation & Maintenance

Construction of the stormwater system will be the responsibility of the developer.

Operation and maintenance of the drainage system will be the responsibility of the Shire of Serpentine Jarrahdale. The surface drainage system will require regular maintenance to ensure its efficient operation. It is considered the following operating and maintenance practices will be implemented periodically :

- removal of debris to prevent blockages;
- street sweeping to reduce particulate build up on road surfaces and gutters;
- cleaning of sediment build up and litter layer on the bottom of detentions storage areas;
- application of slow release/zero phosphorus fertilisers for maintenance of POS areas and any swales;
- undertake education campaigns regarding source control practices to minimise pollutant runoff into stormwater drainage system; and
- checks on subsoil drainage function.

A summary of the proposed maintenance schedule is presented in Table 11 below.

TABLE 11: MAINTENANCE SCHEDULE FOR DRAINAGE INFRASTRUCTURE

Item	Maintenance Interval		
	Quarterly	Biannually	As required
Street Drainage			
Street sweeping to reduce particulate build up	✓		
Eduction of sediment and rubbish in manholes			✓
Removal of debris to prevent blockages	✓		
Swale (bio-retention)			
Inspect for erosion + sediment accumulation		✓	
Assess health of vegetation. Remove dead plants and replace where necessary.	✓		
Removal of sediment and leaf litter layer build up.			✓

5.4 Monitoring Program

The monitoring program has been designed consistent with Joint Australian/ New Zealand Standards (2000a,b,c) to allow quantitative assessment of hydrological impacts of proposed development within the Study Area. In particular, the program addresses the monitoring of surface water discharge from the development and groundwater quality.

The post development monitoring program is designed to operate over a 2 year period. The program will be periodically reviewed to ensure suitability and practicality. The program may need to be modified as data are collected to increase or decrease the monitoring effort in a particular area or to alter the scope of the programme itself. Any modification to the program would require the agreement of all parties (DoW, SSJ, and developer).

All water quality sample testing will be conducted by a NATA approved laboratory.

A summary of the proposed monitoring program and reporting schedule is shown in Table 12, with the frequency of water quality target review and the contingency action plan detailed in Table 13. The 2 year monitoring program is to be undertaken by the developer.

Surface and groundwater monitoring are described below and summarised in Table 12. Ongoing tracking of environmental performance will be undertaken as monitoring data becomes available through a series of consolidated data spreadsheets.

5.4.1 Surface Water

Surface water monitoring includes water quality only.

Discharge at 2 locations (Birrega Main Drain plus one stormwater attenuation area outlet) will be monitored over the first 2 years of development. As the BMD is proposed to be realigned to extend around the Study Area, this location will be on the realigned section of the drain bordering the Study Area. Monthly samples will be taken for laboratory analysis during the winter months when the drain is flowing.

Monitoring of the following parameters is proposed :

- pH, EC, TSS
- Nutrients - TP, TN (with components including FRP, TKN, Nitrate/Nitrite)

5.4.2 Groundwater

Quarterly monitoring of water levels and groundwater quality is proposed. Monitoring at 2 groundwater sites (RH2 and RH3) is proposed using existing bore locations shown in Figure 10. Note these sites may require reinstatement/realignment following construction to suite subdivision design. Any of the bores disturbed during development will be replaced as near as possible to existing bore sites, and re surveyed to Australian Height Datum (AHD).

The depth to water table will be measured by electrical depth probe or an alternative suitable device (eg continuous data logger). Water samples are to be taken after purging the bores to ensure a fresh sample is obtained.

Water quality parameters to be measured are as described above for surface water monitoring.

TABLE 12: POST DEVELOPMENT MONITORING AND REPORTING

Monitoring Type	Parameter	Location	Method	Frequency, Timing & Responsibility	Reporting
Groundwater Level	Water Level (m AHD)	2 monitoring bores providing spatial coverage	Electrical depth probe, logger, or similar	Quarterly for 2 years by developer	Annual reports to be provided by the developer as part of post development monitoring for the Study Area will provided for a period of 2 years. Reports will be submitted to DoW within 3 months of completion of the reporting period.
Groundwater Quality	pH, EC, TSS Nitrogen Phosphorus	2 monitoring bores providing spatial coverage	Pumped bore samples	Quarterly for 2 years (typically Jan, Apr, Jul & Oct) by developer	
Surface Water Quality	pH, EC, TSS Nitrogen Phosphorus	2 locations (BMD and stormwater attenuation area outflow)	Collected grab samples	6 samples annually for 2 years by developer Sampling to capture first flush (if possible), then 4 further samples from June to Oct	Suitability of existing monitoring and reporting frequencies to be assessed annually with any modifications requiring agreement by all parties (DoW,SSJ, & Developer)

5.4.3 Annual Reporting

Reporting is proposed to be annually, co-ordinated by the developer and submitted to the Shire of Serpentine Jarrahdale and DoW for review. The report will compare the monitoring results with target design criteria and performance objectives and determine what, if any, further actions may be necessary, and provide ongoing assessment of the suitability of existing monitoring and reporting frequencies.

Assessment of performance compliance against water quality criteria will require careful consideration to account for inter seasonal and inter annual variability, and as both surface and groundwater quality will be a function of historical land use practices not only within the development area, but over the entire upstream catchment.

The proposed process for contingency action in the assessment of performance compliance is shown in Table 13. Monitoring and reporting outcomes will be used in a continual improvement capacity to review proposed WSUD, and inform the planning and design approaches for other developments.

TABLE 13 : CONTINGENCY PLANNING

Monitoring Type	Criteria for Assessment	Criteria Assessment Frequency	Contingency Action 1. Assess if an isolated, development area or regional occurrence. 2. Determine if due to the development or other external factors. 3. Perform appropriate contingency action as required (examples provided below) 4. Record and report in the annual report any breach and action taken. 5. If necessary, inform residents of any required works and their purpose.
Groundwater Level	Groundwater levels not to exceed CGL in areas of subsoil drainage.	After monitoring occasion	1. Review design and operation of subsoil and stormwater drainage system. 2. Perform maintenance as required.
Groundwater Quality	Nutrient concentrations in shallow bores to be similar or better than interim targets established by predevelopment monitoring.	Annual review of water quality targets	1. Identify and remove any point sources. 2. Reinforce Community Education/Awareness program. 3. Review operational and maintenance (eg fertilising) practices. 4. Consider alterations to POS areas including landscape regimes and soil amendment. 5. Consider modifications to the stormwater system. 6. Consider initiation of community based projects.
Surface Water Quality	Water quality discharging from the Study Area to be similar or better than interim targets established based on existing surface water quality		

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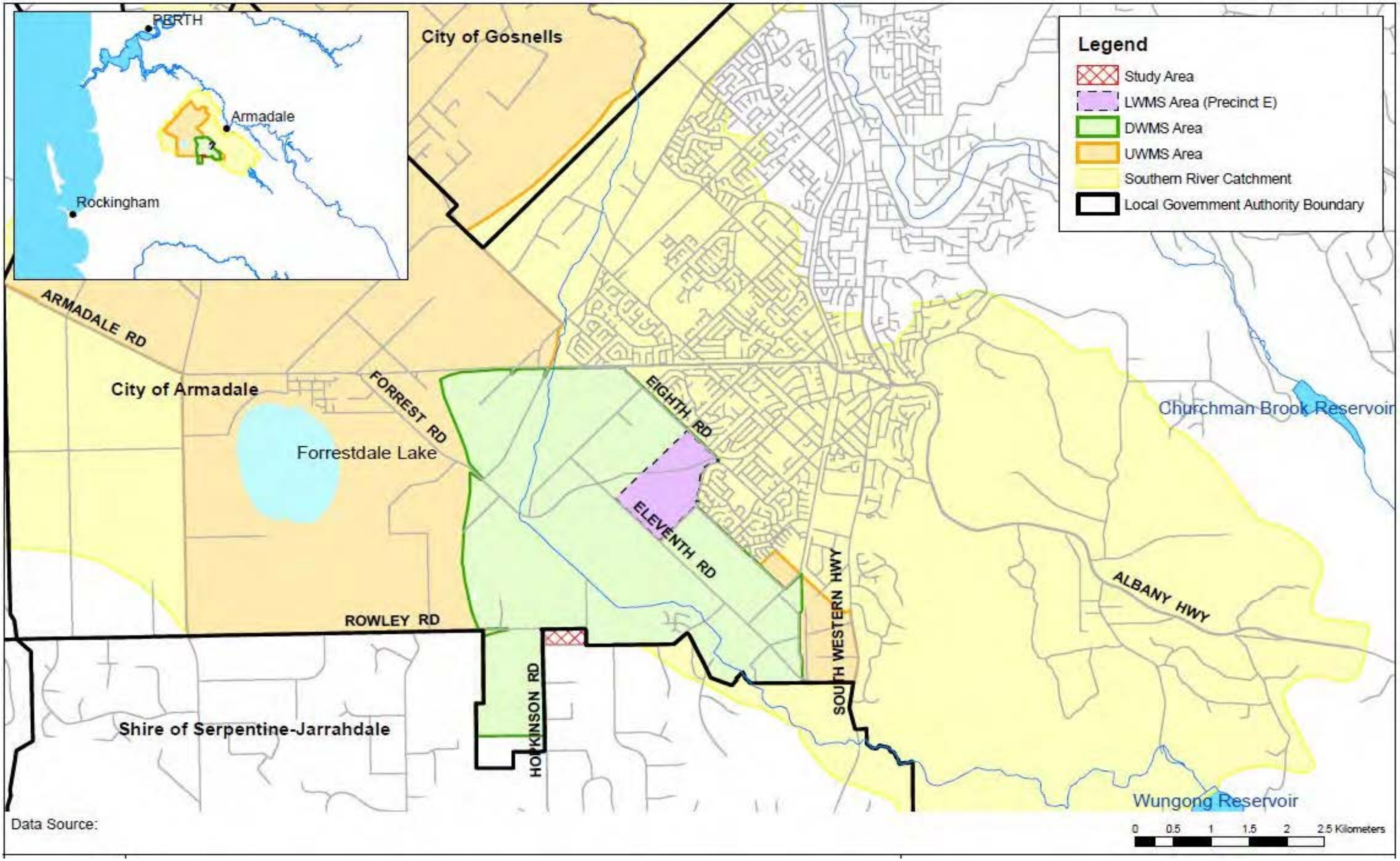
FIGURES



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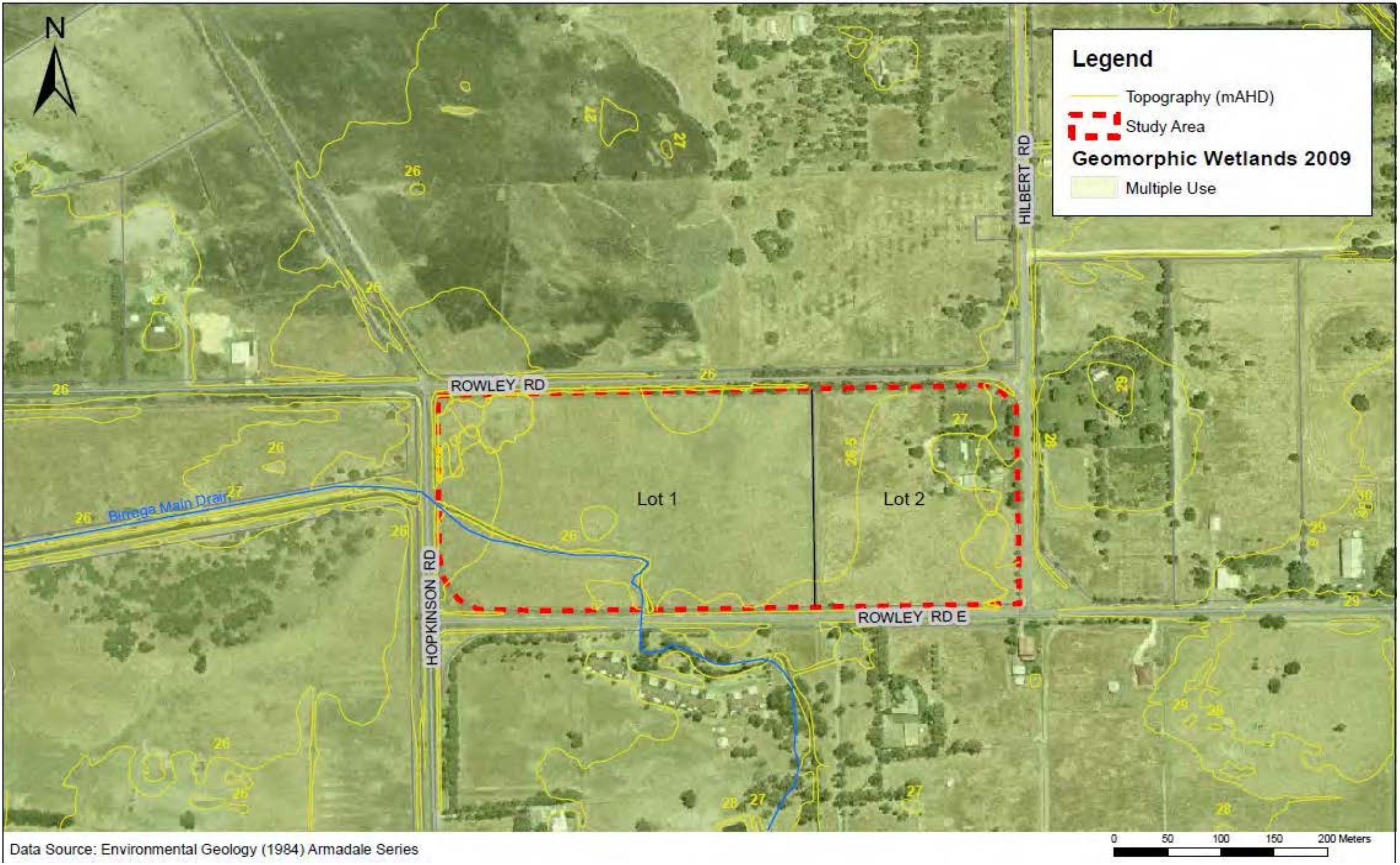
Terranovis
Lots 1 and 2 Rowley Rd, Darling Downs: LWMS
Figure 1:Site Context Plan



Data Source: Environmental Geology (1984) Armadale Series

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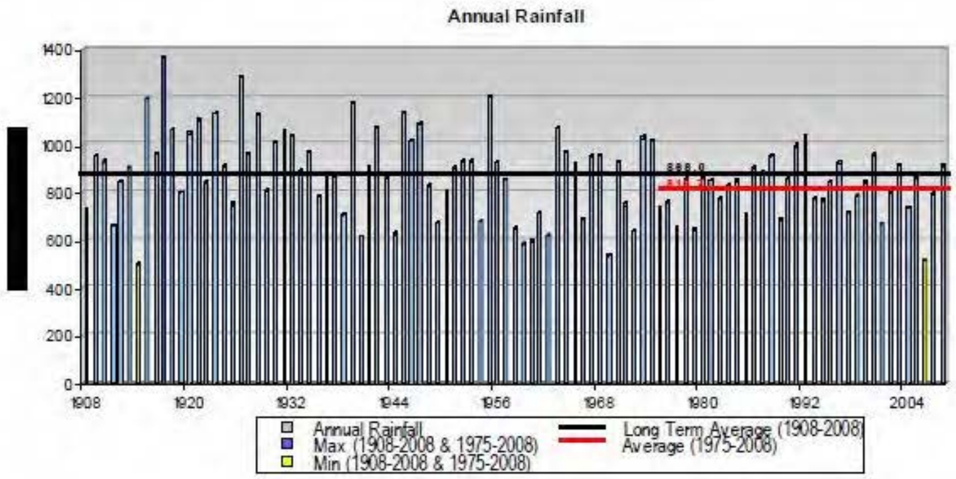
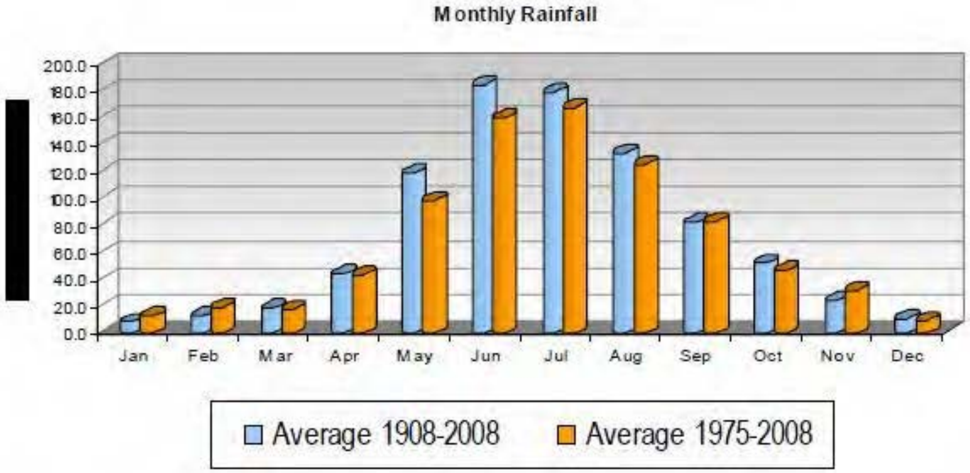
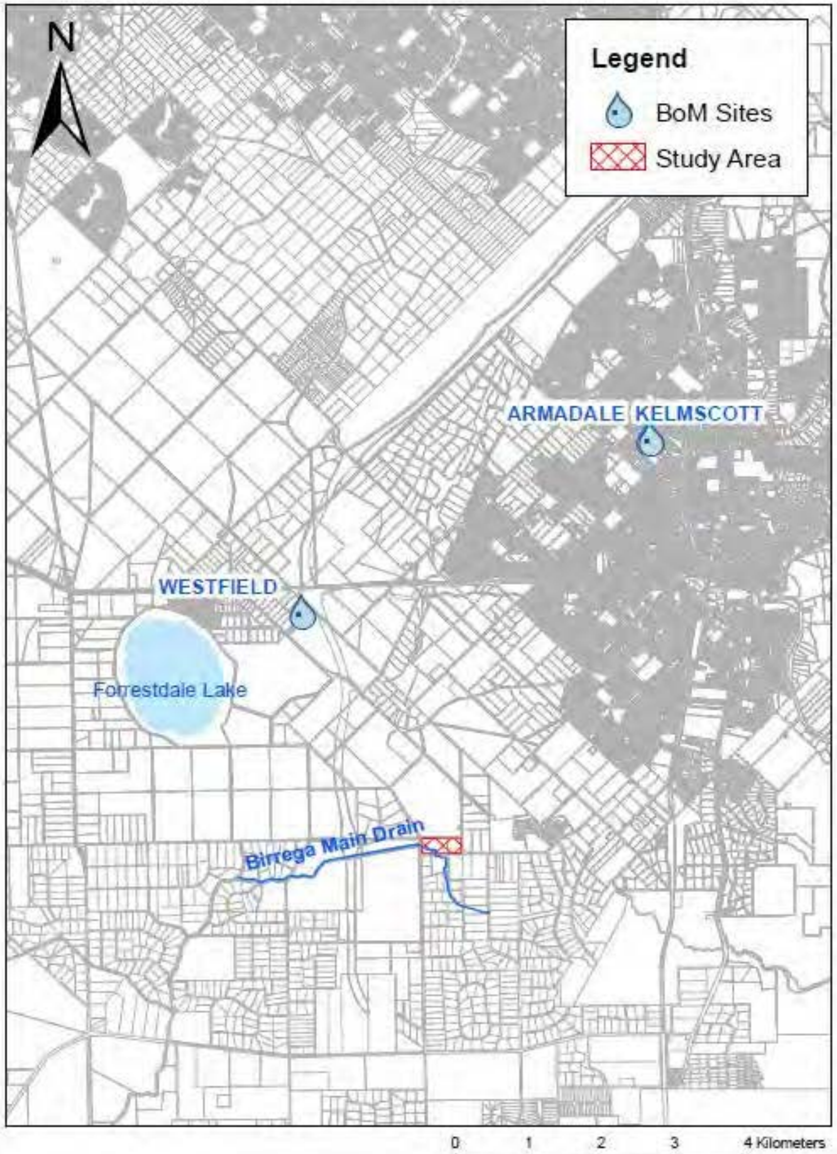
Terranovis
Lots 1 and 2 Rowley Rd, Darling Downs: LWMS
Figure 2:Environmental Mapping







Data Source: Bureau of Meteorology (2008)

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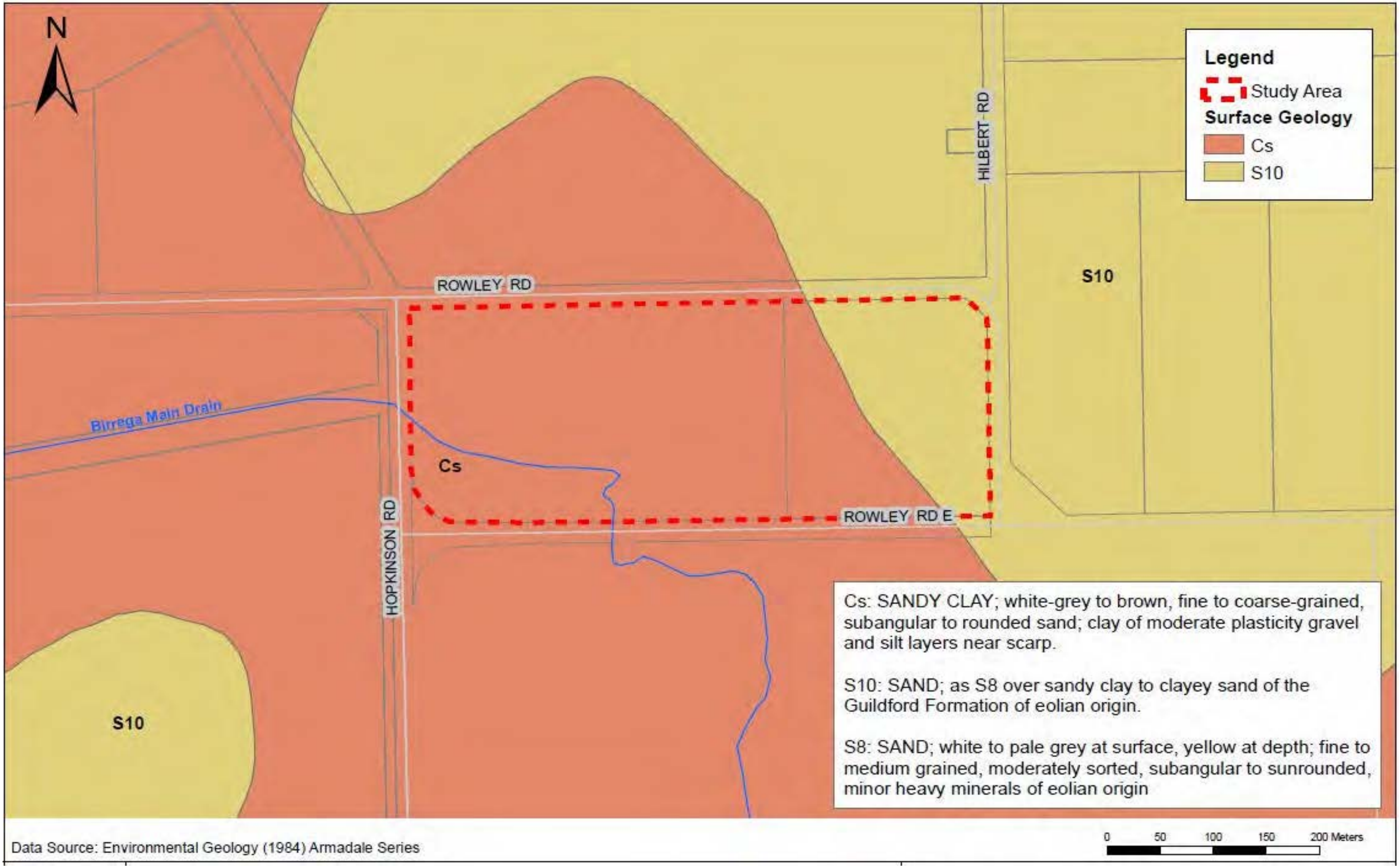
Terranovis
Lots 1 and 2 Rowley Rd, Darling Downs: LWMS
Figure 3: Bureau of Meteorology Rainfall Data



Cs: SANDY CLAY; white-grey to brown, fine to coarse-grained, subangular to rounded sand; clay of moderate plasticity gravel and silt layers near scarp.

S10: SAND; as S8 over sandy clay to clayey sand of the Guildford Formation of eolian origin.

S8: SAND; white to pale grey at surface, yellow at depth; fine to medium grained, moderately sorted, subangular to sunrounded, minor heavy minerals of eolian origin

Data Source: Environmental Geology (1984) Armadale Series

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Job No. J4264
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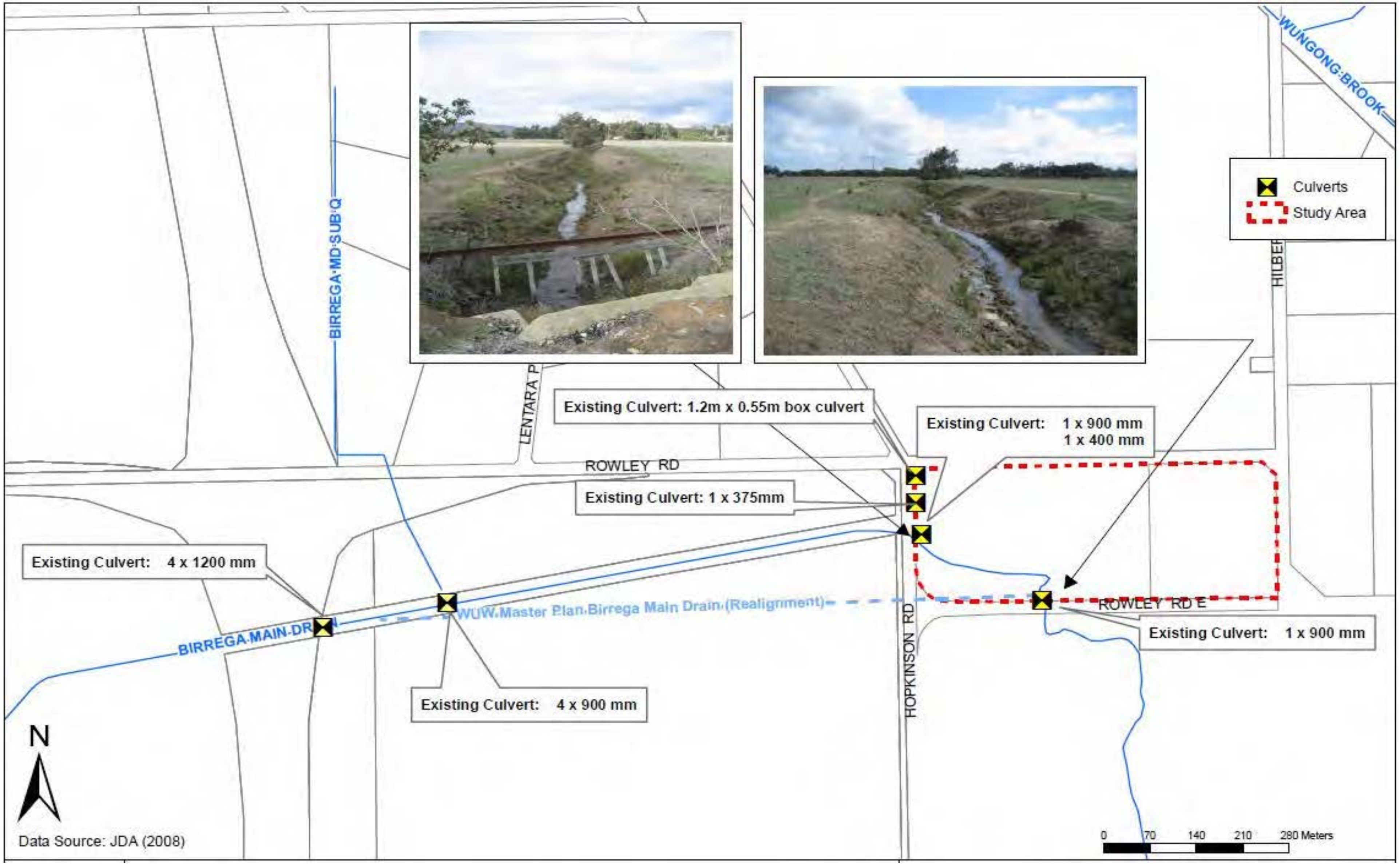
Terranovis
Lots 1 and 2 Rowley Rd, Darling Downs: LWMS
Figure 4: Surface Geology



Data Source: JDA (2008)

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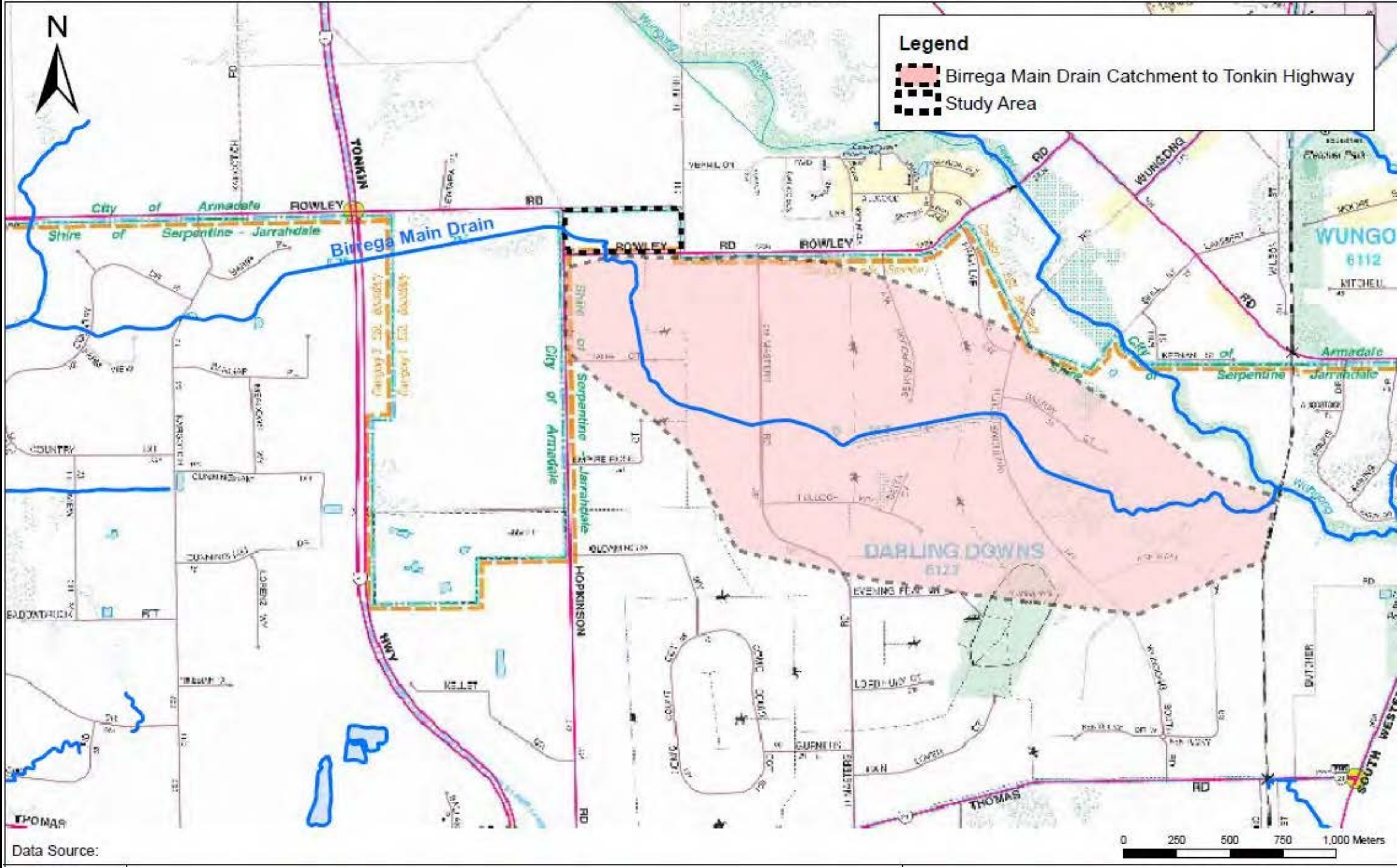
Terranovis
Lots 1 and 2 Rowley Rd, Darling Downs: LWMS
Figure 5: Surface Drainage



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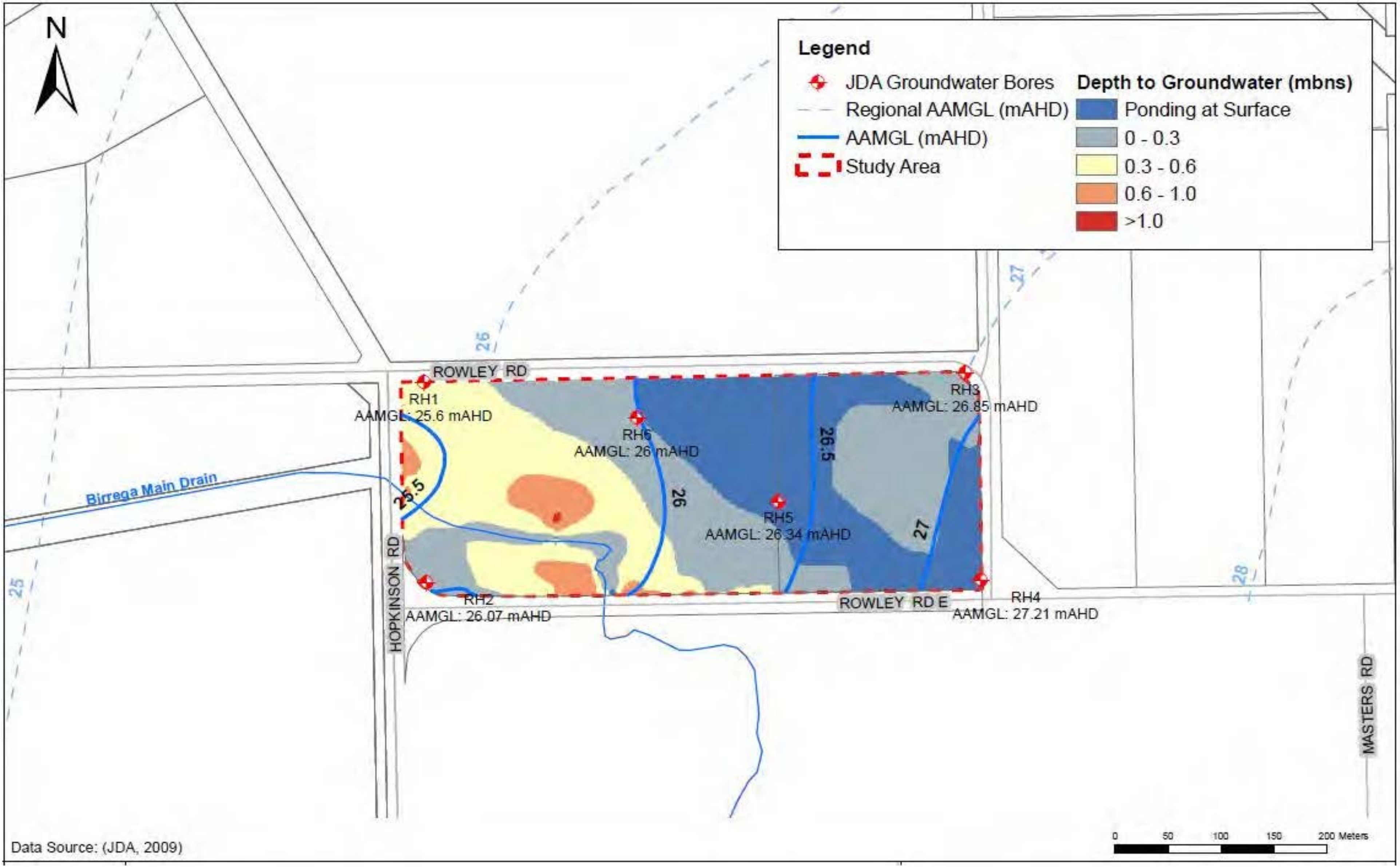
Lots 1 and 2 Rowley Rd, Darling Downs: LWMS
Figure 6: Catchment Area of Birrega Main Drain



Data Source: (JDA, 2009)

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NOTE: mbns - metres below natural surface

Terranovis
Lots 1 and 2 Rowley Rd, Darling Downs: LWMS
Figure 7: Groundwater Mapping

Data Source: Acid Sulfate Soils Series (2008)

Job No. J4264
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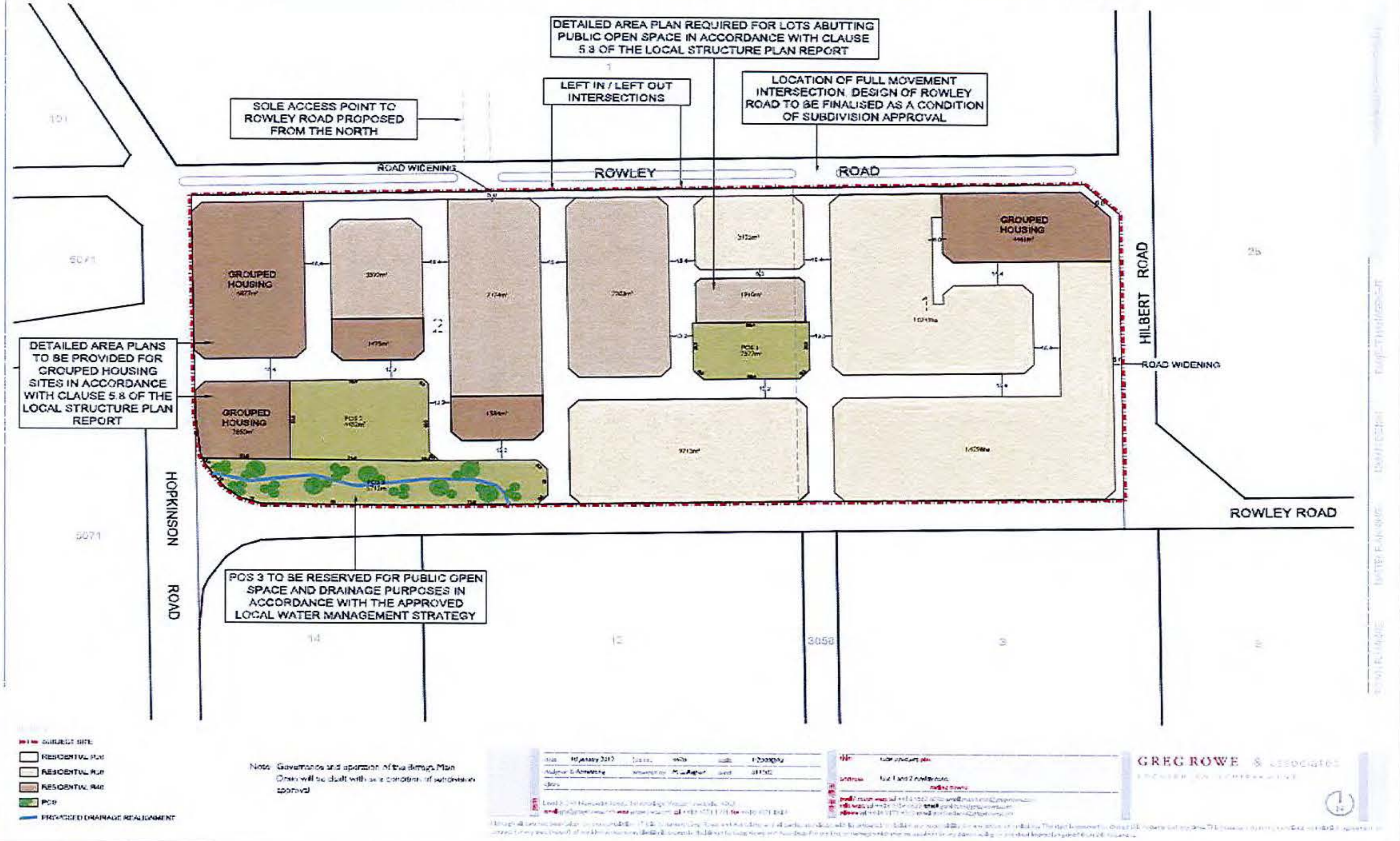
Terranovis
Lots 1 and 2 Rowley Rd, Darling Downs: LWMS
Figure 8: Acid Sulphate Soils Mapping



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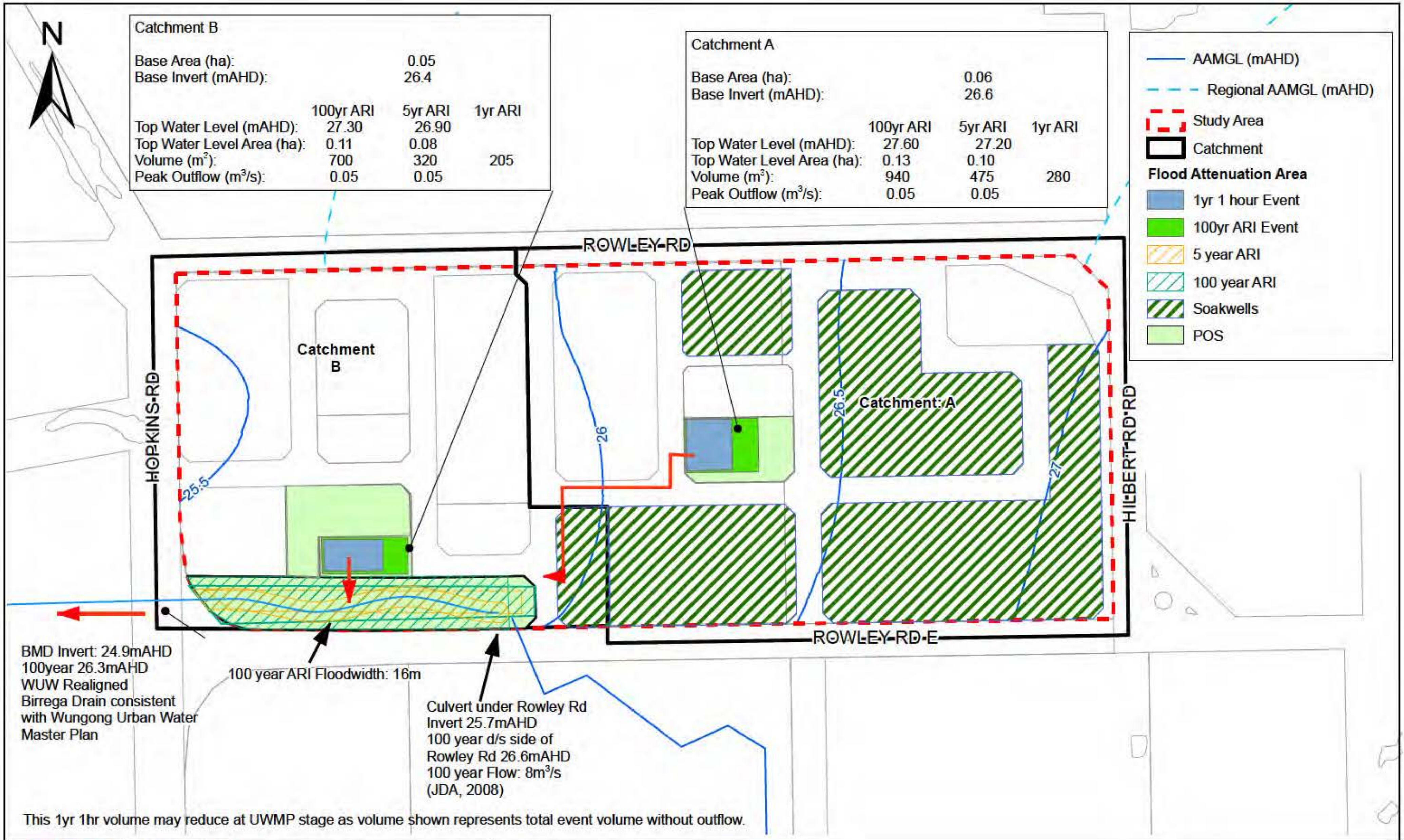
Terranovis

Lots 1 & 2 Rowley Rd, Darling Downs: LWMS

Figure 9: Local Structure Plan (10/1/2012)



Catchment B

Base Area (ha):	0.05		
Base Invert (mAHD):	26.4		
	100yr ARI	5yr ARI	1yr ARI
Top Water Level (mAHD):	27.30	26.90	
Top Water Level Area (ha):	0.11	0.08	
Volume (m^3):	700	320	205
Peak Outflow (m^3/s):	0.05	0.05	

Catchment A

Base Area (ha):	0.06		
Base Invert (mAHD):	26.6		
	100yr ARI	5yr ARI	1yr ARI
Top Water Level (mAHD):	27.60	27.20	
Top Water Level Area (ha):	0.13	0.10	
Volume (m^3):	940	475	280
Peak Outflow (m^3/s):	0.05	0.05	

BMD Invert: 24.9mAHD
100year 26.3mAHD
WUW Realigned
Birrega Drain consistent
with Wungong Urban Water
Master Plan

100 year ARI Floodwidth: 16m

Culvert under Rowley Rd
Invert 25.7mAHD
100 year d/s side of
Rowley Rd 26.6mAHD
100 year Flow: $8m^3/s$
(JDA, 2008)

This 1yr 1hr volume may reduce at UWMP stage as volume shown represents total event volume without outflow.

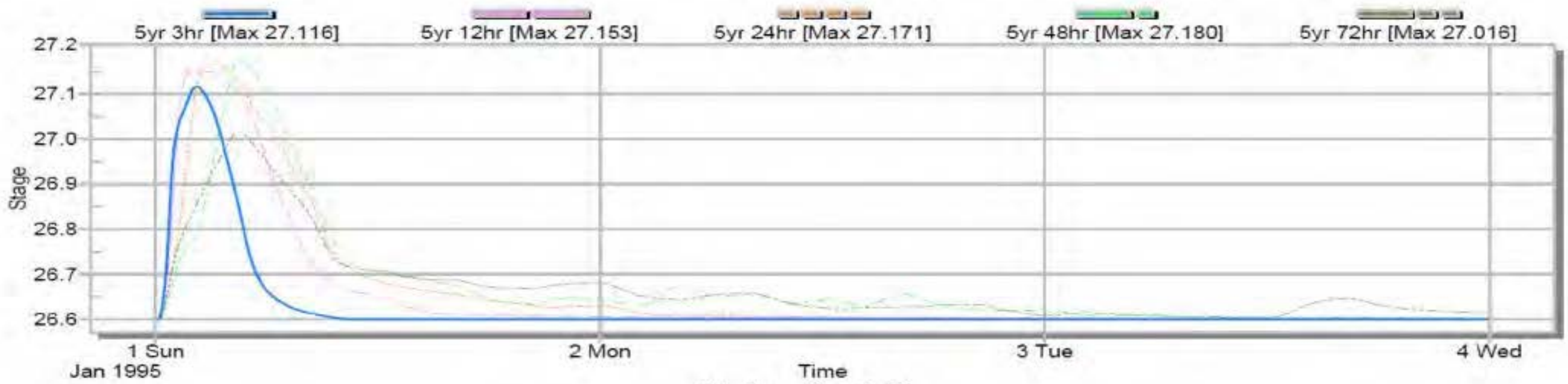
Job No. J4264
Scale 1:3,000

0 50 100
Meters

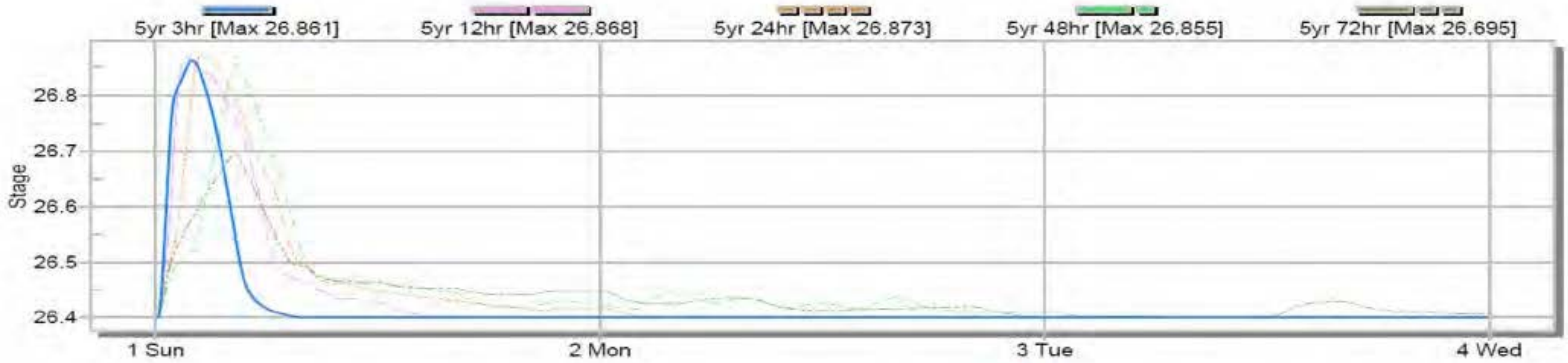
Terranovis
Lots 1 & 2, Rowley Rd, Darling Downs: LWMS

Figure 10: Proposed Urban Water Management System

Node - Catch A



Node - Catch B



Drain Invert: 24.80 mAHD
5 year ARI backwater: 25.6 mAHD (JDA, 2008)

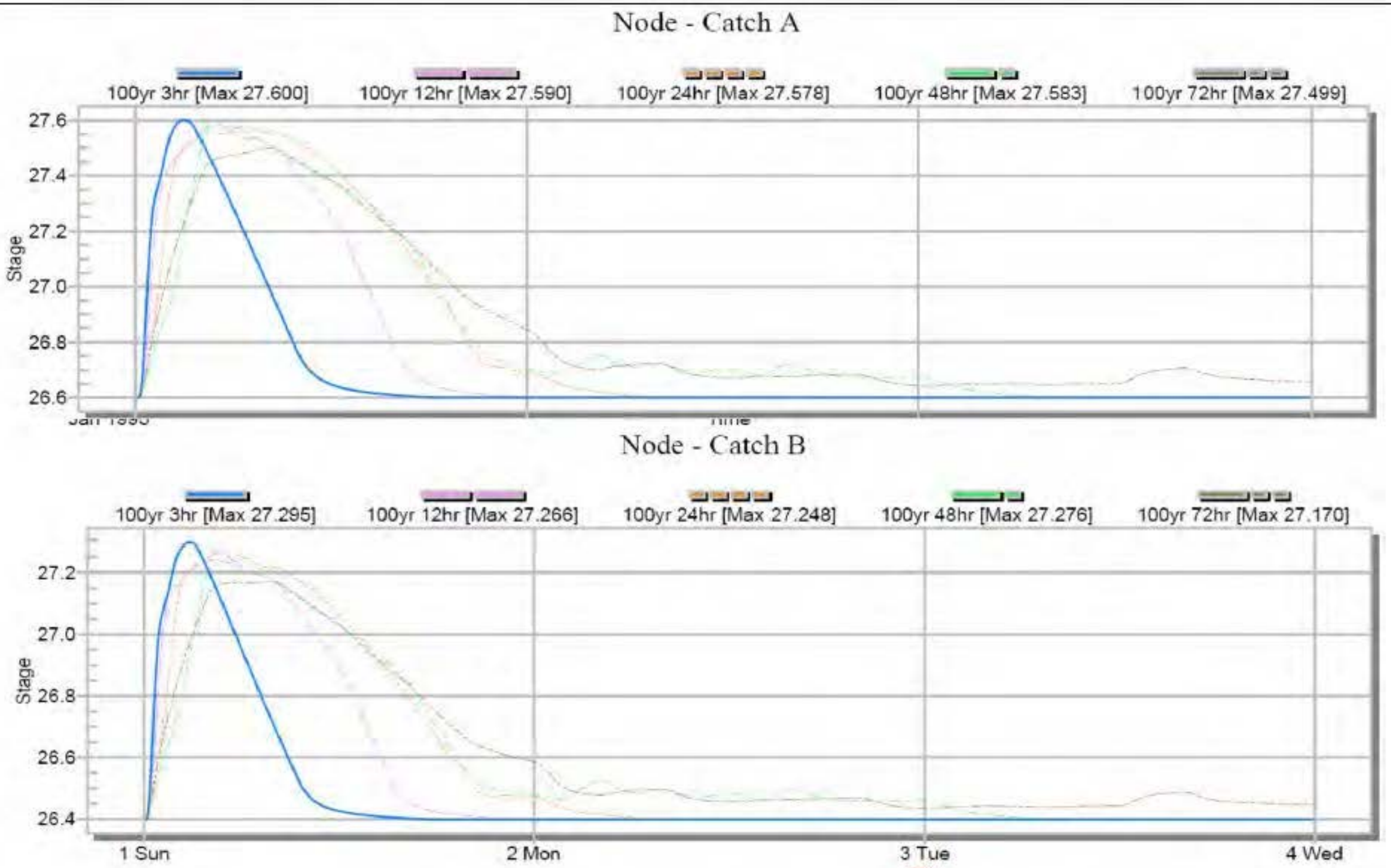
5 year ARI flow from upstream catchment: ~4m³/s
5 year ARI TWL in Birrega @ upstream = 26.50 mAHD

Job No. J4264

N

Terranovis
Lots 1 and 2 Rowley Rd, Darling Downs: LWMS

Figure 11: XP-Storm Modelling Results 5 Year Storm Event



Drain Invert: 24.80 mAHD
100 year ARI backwater: 26.0 mAHD (JDA, 2008)

100 year ARI flow from upstream catchment: ~8m³/s
100 year ARI TWL in Birrega @ upstream = 26.85 mAHD

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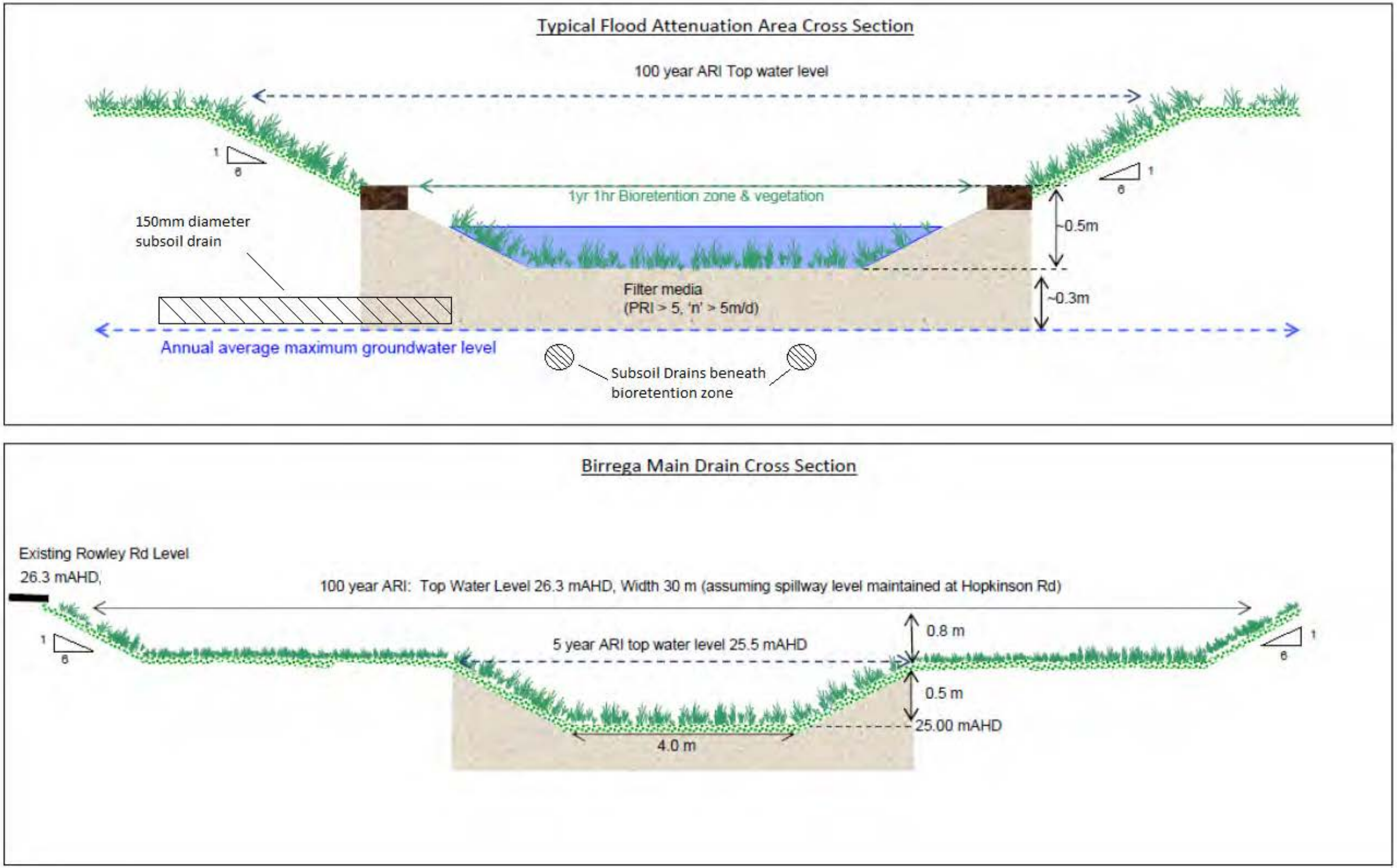
Terranovis
Lots 1 and 2 Rowley Rd, Darling Downs: LWMS
Figure 12: XP-Storm Modelling Results 100 Year Storm Event

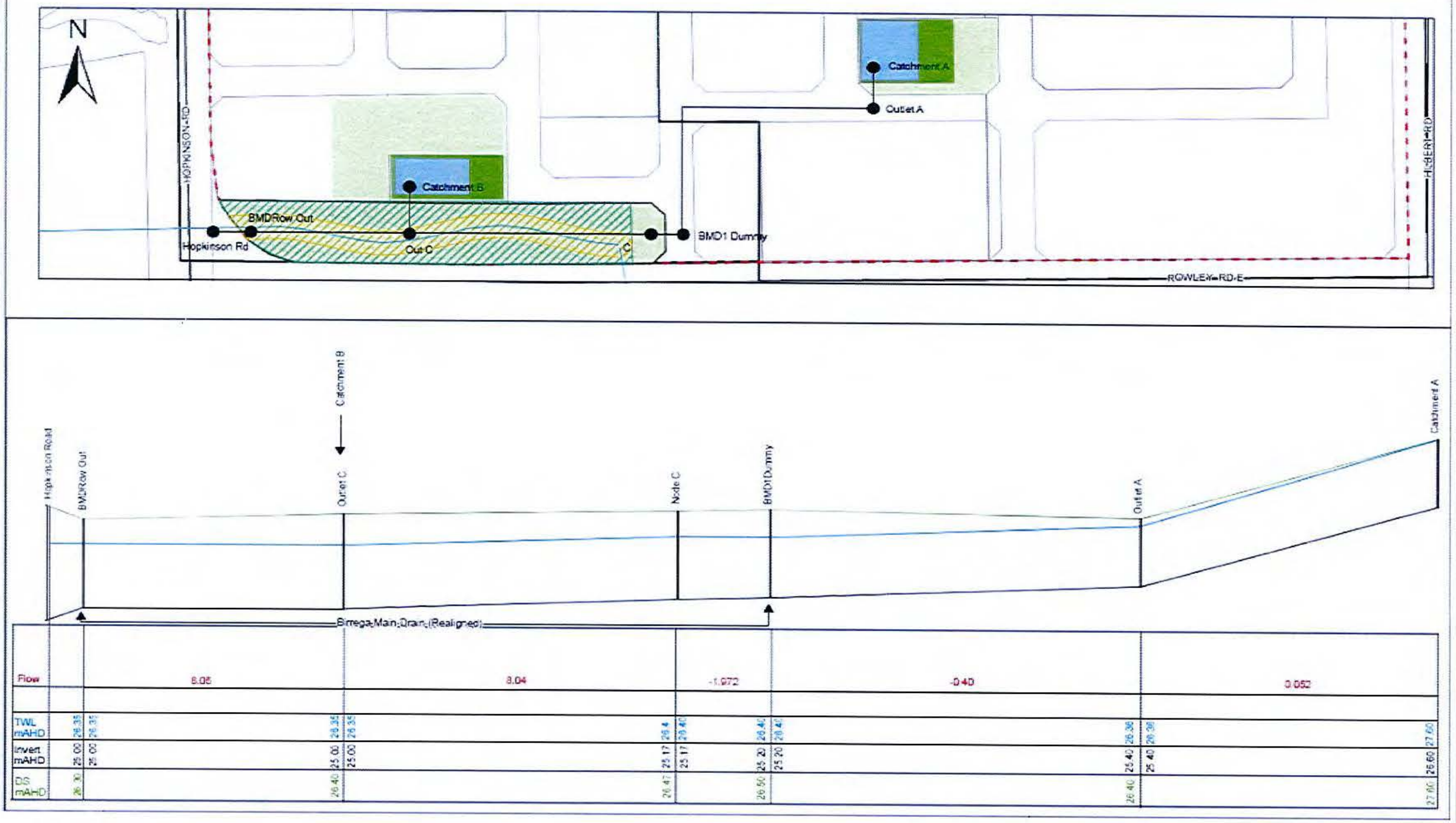

Typical Flood Attenuation Area Cross Section

Birrega Main Drain Cross Section

Job No. J4264
Not to Scale

Terranovis
Lots 1 & 2 Rowley Rd, Darling Downs: LWMS

Figure 13: Proposed Flood Attenuation Area and Birrega Main Drain Cross Section



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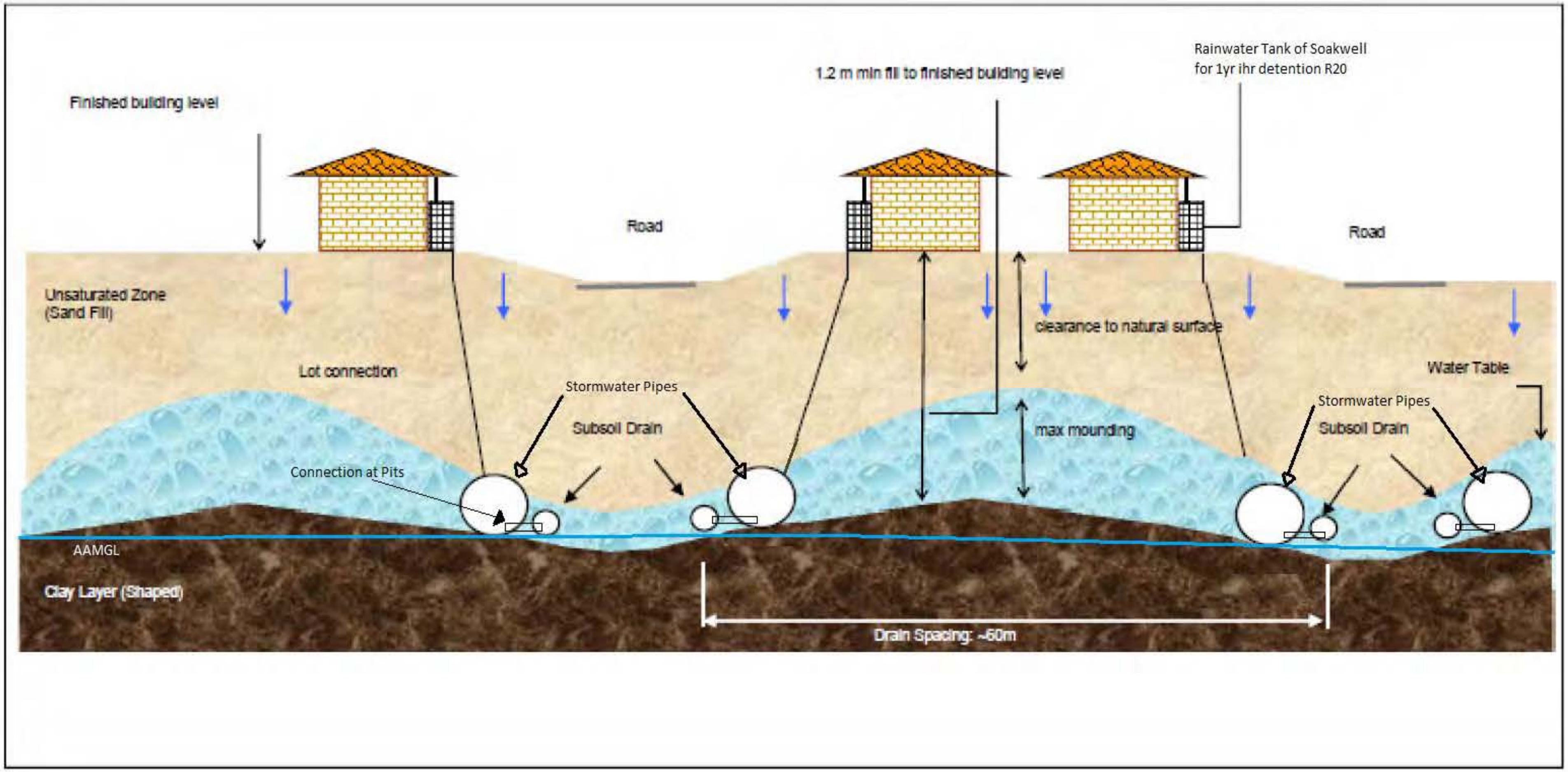
Scale: 1:1,704

0 50 100 150 200 Meters

Terranovis

Lots 1 & 2 Rowley Rd, Darling Downs: LWMS

Figure 14: Birrega Main Drain Long Section



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Terranovis
Lots 1 & 2 Rowley Rd, Darling Downs: LWMS
Figure 15: Subsoil Drainage Schematic

APPENDIX A

Local Water Management Strategy Checklist for Developers

Local Water Management Strategy : Checklist

The following checklist provides a guide to items which should be addressed by developers in the preparation of local water management strategies for assessment by the local authority when an application for a structure plan is lodged.

Applicant: Terranovis
Name of structure plan: Lots 1 and 2 Rowley Road, Darling Downs Shire of Serpentine-Jarrahdale Local Structure Plan

Contact: **Jim Davies, Principal Hydrologist, JDA Consultant Hydrologists**
Address: **Suite 1, 27 York St Subiaco WA 6008**
Telephone number: **9388 2436** Email: **jim@jdahydro.com.au**

Date: **2 March 2012**

	Item	Submission		Assessment	
		LWMS Ref [1]	Comment [2]	Compliance	Comment
1.0	**Introduction**	Chapter 1	-		
1.1	Drainage and water management principles and design objectives for this structure plan	Section 1.3	-		
1.2	Planning background (subject land)	Section 1.1	-		
1.3	Previous studies (related to drainage and water)	Section 1.2	-		
2.0	**Proposed development**	Chapter 3, Figure 9			
2.1	Key elements of structure plan	Chapter 3, Figure 9	-		
2.2	Previous land use and potential sources of contamination	Sections 2.8, 2.4.3, 2.5.3, and 4.5	No known contaminated sites. Pre development water quality monitoring summaries provided and estimates of existing nutrient inputs.		
2.3	Finished lot levels – (determined by greater of 100 year flood protection criteria or minimum separation of building foundations to MGL or CGL)	Section 4.3	Criteria specified. Fill levels to be established in detailed design and reported in UWMP.		
3.0	**Existing site characteristics**	Chapter 2	-		
3.1	Topography and landform identified	Section 2.1, Figure 2	-		
3.2	Environmental geology of the site identified (including soil types, ASS and PASS)	Section 2.3, Figures 4 and 8	-		
3.3	Soil hydraulic conductivity and infiltration capacity of the site identified	-	Based on lithological logs and Environmental Geology mapping, some opportunities for lot scale		

	Item	Submission		Assessment	
		LWMS Ref [1]	Comment [2]	Compliance	Comment
			infiltration exist with introduction of imported fill. To be examined with detailed geotechnical investigations at UWMP stage.		
3.4	Groundwater levels, flows and quality of the site mapped (include identification and monitoring of any local or regional groundwater bores)	Section 2.5, Figure 7 and Appendices E & F	-		
3.5	Surface water flows and quality of the site identified (include flow monitoring of existing drainage)	Section 2.4, Appendix C and Figures 5 and 6	-		
3.6	Environmental assets and water-dependent ecosystems mapped	Section 2.6	No known environmental assets within the Study Area		
3.7	Indigenous sites identified	-	Refer Local Structure Plan document		
3.8	Existing infrastructure and constraints to design identified (include management strategies for any identified constraints)	-	Site is vacant land – no infrastructure constraints.		
3.9	Site water balance pre-development and postdevelopment identified	Section 4.1.3	Lot scale water balance committed to be performed at UWMP stage based on agreed measures.		
3.10	Water Sustainability Initiatives	Section 4.1.2	-		
4.0	**Stormwater management**	Section 4.2	-		
4.1	Pre- and post-development hydrology (1 year, 5 year and 100 year ARI events)	Section 2.4 and 4.2 Figures 5,6 and 10-12 Table 6 and Appendix C	-		
4.2	1 year ARI event managed for ecological protection in accordance with *Drainage and water management plan*	Section 4.2.2 & 4.2.3 Table 6	1 Year ARI volumes identified for water quality treatment		
4.3	5 year ARI event managed for serviceability in accordance with *Drainage and water management plan*	Section 4.2.2 & 4.2.3 Table 6	5 year flood storages and flows identified		
4.4	100 year ARI event managed for flood protection in accordance with *Drainage and water management plan* (include flow paths and emergency access routes and fully identify flood plain and protection measures)	Section 4.2.2 & 4.2.3 Table 6	100 year flood storages and flows identified		
4.5	Finished lot levels at minimum of 0.5m above 100-year ARI flood levels.	Section 4.2.1	-		
4.6	POS credits identified	Table 6	Areas for 5 year ARI and area of overall POS detailed for assessment if required.		
4.7	Water quality management BMPs to achieve design targets:	Section 4.5 Table 6 and 7	Areas set aside in the LWMS for water quality treatment are shown in		

	Item	Submission		Assessment	
		LWMS Ref [1]	Comment [2]	Compliance	Comment
	Vegetated bioretention systems sized at 2% of the constructed impervious area they receive runoff from OR to achieve: at least 80% reduction of total suspended solids at least 60% reduction of total phosphorus at least 45% reduction of total nitrogen at least 70% reduction of gross pollutants	Figure 10	Figure 10. Bioretention systems are to be sized and designed as part of the UWMP. BMP performance is described in Section 4.5.2 and outlined in Table 7.		
5.0	**Groundwater management**	Section 4.3	-		
5.1	Groundwater level management strategy	Section 4.3	Combination of fill and subsoil drainage to be applied		
5.2	Bio-retention system, subsurface drainage and drainage inverts	-	Drainage inverts, subsoil design and bioretention system design are detailed design issue. Will be addressed in preparation of a UWMP.		
5.3	Subsurface drainage design	-	Drainage inverts, subsoil design and bioretention system design are detailed design issue. Will be addressed in preparation of a UWMP.		
5.4	Groundwater management strategies to achieve: at least 60% reduction of total P at least 45% reduction of total N	Section 4.5	-		
5.5	Discharge to water-dependent ecosystems	Section 4.5.2	Demonstrated compliance with DoW and PDC(2006) requirements		
5.6	Specifications for imported fill (where proposed)	-	Fill specification a UWMP issue. The use of fill to achieve separation from groundwater addressed in Section 4.3		
6.0	**Monitoring**	Section 2.4, 2.5 and Section 5.4	-		
6.1	Predevelopment monitoring	Section 2.4, 2.5 and Section 5.4	Predevelopment monitoring completed. Post development program provided		
6.2	Monitoring/sampling to follow Australian Standards	Section 4.5	-		
6.3	Monitoring/sampling locations	Section 4.5, Figure 10	-		
6.4	Water quality parameters to be monitored	Section 4.5, Table 11	-		
6.5	Monitoring program to include a contingency action plan to manage risk	Table 12	-		
7.0	**Implementation**	Chapter 5	-		
7.1	Commitments	Chapter 5, Table 9-12	-		
7.2	Maintenance schedules	Section 5.3, Table 10	-		
7.3	Roles and responsibilities (for pre-development,	Tables 9,10,11,12	-		

	Item	Submission		Assessment	
		LWMS Ref [1]	Comment [2]	Compliance	Comment
	during construction and all periods postdevelopment)				
7.4	Funding	Section 5.1, Table 9	Summary table of roles and responsibilities included in Section 5.1		
7.5	Review	Section 5.3 & Section 5.4.3, Table 10	Includes maintenance, review of system performance, reporting requirements		

[1] Identify the section in the local structure plan in which this item has been addressed. It is possible that some items are not applicable and if this is the case, please put an explanation in the comments section.
[2] Please make comments as to the applicability of this criterion.

APPENDIX B

WA Stormwater Management Objectives, Principles and Delivery Approach (DoW 2007) & Decision Process for Stormwater Management in WA (DoE & SRT, 2005)

Western Australian Stormwater Management Objectives

Water Quality
To maintain or improve the surface and groundwater quality within the development areas relative to pre development conditions.

Water Quantity
To maintain the total water cycle balance within development areas relative to the pre development conditions.

Water Conservation
To maximise the reuse of stormwater.

Ecosystem Health
To retain natural drainage systems and protect ecosystem health.

Economic Viability
To implement stormwater management systems that are economically viable in the long term.

Public Health
To minimise the public risk, including risk of injury or loss of life, to the community.

Protection of Property
To protect the built environment from flooding and waterlogging.

Social Values
To ensure that social, aesthetic and cultural values are recognised and maintained when managing stormwater.

Development
To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles.

Western Australian Stormwater Management Principles

- Incorporate water resource issues as early as possible in the land use planning process.
- Address water resource issues at the catchment and sub-catchment level.
- Ensure stormwater management is part of total water cycle and natural resource management.
- Define stormwater quality management objectives in relation to the sustainability of the receiving environment.
- Determine stormwater management objectives through adequate and appropriate community consultation and involvement.
- Ensure stormwater management planning is precautionary, recognises inter-generational equity, conservation of biodiversity and ecological integrity.
- Recognise stormwater as a valuable resource and ensure its protection, conservation and reuse.
- Recognise the need for site specific solutions and implement appropriate non-structural and structural solutions.

Stormwater Delivery Approach for WA

Protect water quality
Stormwater remains clean and retains its high value

Implement best management practice on-site.
Implement non-structural controls, including education and awareness programs.
Install structural controls at source or near source.
Use in-system management measures.
Undertake regular and timely maintenance of infrastructure and streetscapes.

Protect infrastructure from flooding and inundation
Stormwater runoff from infrequent high intensity rainfall events is safely stored and conveyed

Safe passage of excess runoff from large rainfall events towards watercourses and wetlands.
Store and detain excess runoff from large rainfall events in parks and multiple use corridors.
Safely convey excessive groundwater to the nearest watercourse.

Minimise runoff
Slow the migration of rainwater from the catchment and reduce peak flows

Retain and infiltrate rainfall within property boundaries.
Use rainfall on-site or as high in the catchment as possible.
Maximise the amount of permeable surfaces in the catchment.
Use non-kerbed roads and carparks.
Plant trees with large canopies over sealed surfaces such as roads and carparks.

Maximise local infiltration
Fewer water quality and flooding problems

Minimise impervious areas.
Use vegetated swales.
Use soakwells and minimise use of piped drainage systems.
Create vegetated buffer and filter strips.
Recharge the groundwater table for local bore water use.

Make the most of nature's drainage
Cost effective, safe and attractive alternatives to pipes and drains

Retain natural channels and incorporate into public open space.
Retain and restore riparian vegetation to improve water quality through bio-filtration.
Create riffles and pools to improve water quality and provide refuge for local flora and fauna.
Protect valuable natural ecosystems.
Minimise the use of artificial drainage systems.

Minimise changes to the natural water balance
Avoid summer algal blooms and midge problems and protect our groundwater resources

Retain seasonal wetlands and vegetation.
Maintain the natural water balance of wetlands.
No direct drainage to Conservation Category Wetlands or their buffers, or to other conservation value wetlands or their buffers, where appropriate.
Recharge groundwater by stormwater infiltration.

Integrate stormwater treatment into the landscape
Add value while minimising development costs

Public open space systems incorporating natural drainage systems.
Water sensitive urban design approach to road layout, lot layout and streetscape.
Maximise environmental, cultural and recreational opportunities.

Convert drains into natural streams
Lower flow velocities, benefit from natural flood water storage and improve waterway ecology

Create stable streams, with a channel size suitable for 1 in 1 year ARI rainfall events, equivalent to a bankfull flow.
Accommodate large and infrequent storm events within the floodplain.
Create habitat diversity to support a healthy, ecologically functioning waterway.

Note: Selection of appropriate methods should be determined by site conditions.

Decision Process for Stormwater Management in WA
(Department of Environment and Swan River Trust, 2005)

Preamble

The *Decision Process for Stormwater Management in WA* provides a decision framework for the planning and design of stormwater management systems. The methodology outlined in the decision process will result in minimising potential changes in the volume of surface water flows and peak flows which, if not managed, would lead to adverse impacts on water regime, water quality, habitat diversity and biodiversity in receiving water bodies[1] resulting from land development (i.e. residential, rural-residential, commercial and industrial). The process also addresses the management of flood events for the protection of properties. The decision process sits within the objectives, principles and delivery approach outlined in the *Stormwater Management Manual for Western Australia* (DoE, 2004). This includes: minimising risk to public health and amenity; implementing systems that are economically viable in the long term; and ensuring that social, aesthetic and cultural values are maintained.

A significant stormwater management measure is to minimise the 'effective imperviousness' of a development area. Effective imperviousness is defined as the combined effect of the proportion of constructed impervious surfaces in the catchment, and the 'connectivity' of these impervious surfaces to receiving water bodies. The purpose of minimising effective imperviousness is to reduce the transportation of pollutants to receiving water bodies and to retain the post development hydrology as close as possible to the pre-development hydrology. This is achieved by 'disconnecting' constructed impervious areas from receiving water bodies and by reducing the amount of constructed impervious areas.

To retain the pre-development hydrology of a site, the order of management priorities is: the magnitude of peak flows; the volume of catchment run-off; and the seasonality of catchment run-off.

Rainfall, for the majority of events occurring each year, should be retained[2] or detained[3] on-site (i.e. as high in the catchment and as close to the source as possible, subject to adequate site conditions). Runoff from constructed impervious areas (e.g. roofs and paved areas) should be retained or detained through the use of soakwells, pervious paving, vegetated swales or gardens. For detention systems, the peak 1 year Average Recurrence Interval (ARI[4]) discharge from constructed impervious areas should be attenuated to the pre-development discharge rate. Events larger than 1 year ARI can overflow 'off-site'.

For larger rainfall events (i.e. greater than 1 year ARI events), runoff from constructed impervious areas should be retained or detained to the required design storm event in landscaped retention or detention areas in public open space or linear multiple use corridors. Any overflow of runoff towards waterways and wetlands should be by overland flow paths across vegetated surfaces. Further detention may be required to ensure that the pre-development hydrologic regime of the receiving water bodies is largely unaltered, particularly in relation to peak flow rates and, where practical, discharge volume.

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[1] Water bodies are defined as waterways, wetlands, coastal marine areas and groundwater aquifers.

[2] Retention is defined as the process of preventing rainfall runoff from being discharged into receiving water bodies by holding it in a storage area. The water may then infiltrate into groundwater, evaporate or be removed by evapotranspiration of vegetation. Retention systems are designed to prevent off-site discharges of surface water runoff, up to the design ARI event.

[3] Detention is defined as the process of reducing the rate of off-site stormwater discharge by temporarily holding rainfall runoff (up to the design ARI event) and then releasing it slowly, to reduce the impact on downstream water bodies and to attenuate urban runoff peaks for flood protection of downstream areas.

[4] ARI is defined as the average, or expected, value of the periods between exceedances of a given rainfall total accumulated over a given duration. For further information, refer to *Australian Rainfall & Runoff* (IEA, 2001) and the Bureau of Meteorology website via <www.bom.gov.au/hydro/has/ari_aep.shtml>.

Urban pollutants, whether in particulate or soluble forms, are conveyed by stormwater almost every time a storm event occurs. Studies in urban areas have shown that there is no general trend of increased concentrations of contaminants such as nutrients and metals with increasing storm sizes. Figure 1 shows that most hydraulic structures can be expected to treat over 99% of the expected annual runoff volume when designed for a 1 year ARI peak discharge. Unlike flood mitigation measures, stormwater quality treatment devices do not need to be designed for rainfall events of high ARI to achieve high hydrologic effectiveness (i.e. the percentage of mean annual runoff volume subjected to treatment) and therefore a high level of beneficial environmental outcomes.

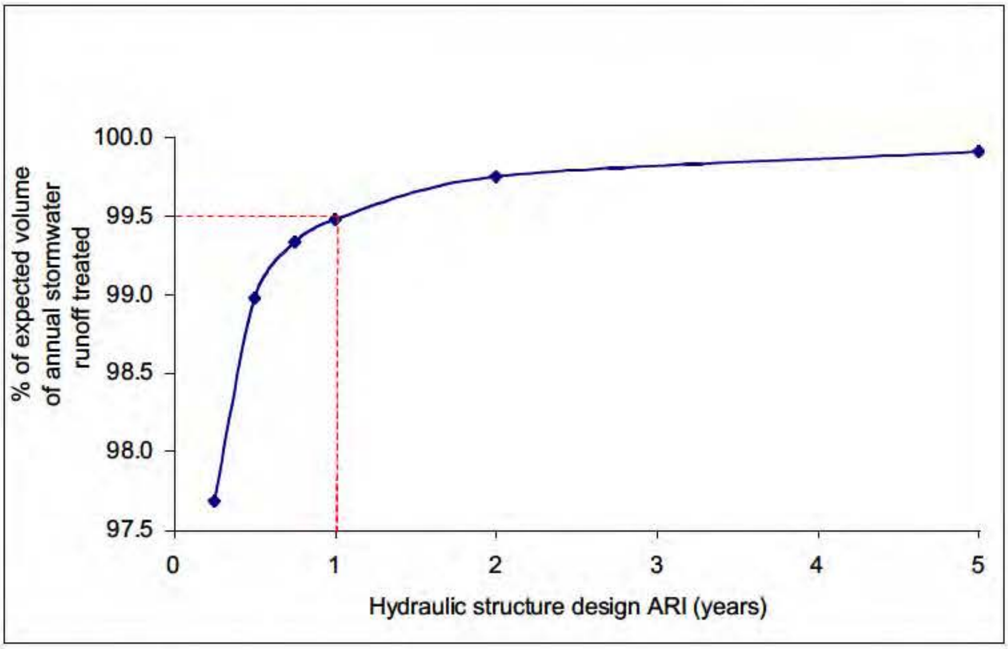

Figure 1. Treatment efficiency of stormwater hydraulic structures for Perth, Western Australia (adapted from Wong, 1999)

Stormwater management systems should be based on adequate field investigations and the conditions of the site. Prior to design, developers should consult with the Department of Environment, local government authority and other relevant stakeholders. For further information, refer to the *Decision Process for Stormwater Management in WA* flow chart.

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Decision Process for Stormwater Management in WA (DoE and SRT, 2005)

1. Stormwater management systems shall be designed in accordance with the objectives, principles and delivery approach outlined in the *Stormwater Management Manual for Western Australia* (DoE, 2004). This includes: minimising risk to public health and amenity; protecting the built environment from flooding and waterlogging; implementing systems that are economically viable in the long term; and ensuring that social, aesthetic and cultural values are maintained.
2. Prior to design, developers shall consult with the Department of Environment (DoE), local government authorities and other relevant stakeholders. Maintenance requirements should be considered at this stage.
3. Adequate field investigations shall be undertaken to determine the appropriate hydrologic regime for the site and potential site constraints, such as contaminated sites, acid sulfate soils or highly elevated nutrient levels in groundwater. Baseline and/or ongoing monitoring of groundwater and surface water quality and quantity may be required.
4. Stormwater management systems may be subject to additional design and performance criteria if they have the potential to impact on sensitive receiving environments. Sensitive receiving environments include (but are not limited to) conservation areas or reserves, wetlands and waterways with conservation values, Waterways Management Areas, the Swan River Trust Management Area, Environmental Protection Policy areas, and some areas of native vegetation. Sensitive native vegetation includes (but is not limited to) Declared Rare Flora, Priority Species, Threatened Ecological Communities, Threatened Fauna Habitat and vegetation identified in *Bush Forever* (WAPC, 2000), including vegetation located east of the Southern River Vegetation Complex on the Swan Coastal Plain.

Water quantity management

1. Is the proposal completely or partly within a known contaminated site (i.e. a contaminated site listed on the contaminated sites register, or identified through adequate field investigations) or high acid sulfate soil risk area?
2. Does the soil or groundwater contain *highly elevated* nutrient levels? A definition for highly elevated nutrient levels has not been provided, as nutrient breakthrough is highly variable and is dependent on the soil type (e.g. organic, clay and iron oxyhydroxide content) and local wetting and drying cycles.

Yes (to either question)

Avoid mobilisation or disturbance of the in-situ contaminants

If yes to question 1 - seek further advice from the DoE.

If yes to question 2 - consult with the DoE about best management practices to minimise nutrient leaching through the soil profile (i.e. structural and non-structural controls suitable to the site conditions).

No (most situations)

1. Maintain the pre-development hydrologic regime and meet the ecological water requirements of the receiving environment.
2. Hydraulic requirements shall be determined by ecosystem requirements and the hydrologic form of the local and downstream environment. Physical survey measurements and a biological survey should be undertaken.
3. Hydrologic and hydraulic analyses, modelling and design shall incorporate the recommendations and methodology of *Australian Rainfall and Runoff, A Guide to Flood Estimation* (IEA, 2001).
4. The effective imperviousness of a development shall be minimised. The process for achieving this is outlined below:

Less than and up to 1 year ARI events

Generally, rainfall from 1 year average recurrence interval (ARI) events should be retained or detained on-site (i.e. as high in the catchment and as close to the source as possible), unless it can be clearly demonstrated that achievement of this objective is impractical due to site conditions.

Generally, for detention systems, preserve the pre-development 1 year ARI peak discharge rate. Use best management practices (structural and non-structural) to treat water quality.

Greater than 1 year and up to 100 year ARI events

Mitigate runoff from constructed impervious areas for greater than 1 year ARI events, in landscaped retention or detention areas in public open space or linear multiple use corridors. Any overflow of runoff towards waterways and wetlands shall be by overland flow paths across vegetated surfaces.

Design for greater than 1 year and less than 10 year ARI events

Minor system conveyance
(i.e. swales and pipes).

Design for 10 year to 100 year ARI events

Major system conveyance
(i.e. via overland flow).

Water quality management

1. On-site field investigations are required to determine the appropriate water quality management measures for the site, including consideration of potential pathways of nutrients towards receiving water bodies. Receiving water bodies are defined as waterways, wetlands, coastal marine areas and groundwater aquifers.
2. The components of the water quality treatment train must be designed so that their combined effect meets the water quality management objectives as specified in the relevant regional water quality management targets (e.g. local government stormwater management plans, the Regional Natural Resource Management Strategy, *Swan-Canning Cleanup Program Action Plan* (SRT, 1999) and the *Environmental Protection (Peel Inlet-Harvey Estuary) Policy 1992* (EPA, 1992)). The requirements for demonstration of compliance shall depend upon the scale of the proposed land development. Demonstration of compliance may be achieved by the use of appropriate assessment methods, to the satisfaction of DoE.

Protect waterways and wetlands

1. Retain and restore waterways and wetlands. For waterways, the approach should be consistent with the *River Restoration Manual* (WRC, 1999-2003), *Draft Waterways WA - A Policy for Statewide Management of Waterways in Western Australia* (WRC, 2000), *Foreshore Policy 1 - Identifying the Foreshore Area* (WRC, 2002) and, in the Swan and Canning Catchments, the *Environmental Protection (Swan and Canning Rivers) Policy 1998* (EPA, 1998). For wetlands, the approach should be consistent with the *Environmental Protection of Wetlands Position Statement No. 4* (EPA, 2004) and the *Wetlands Conservation Policy for WA* (Government of WA, 1997). On the Swan Coastal Plain, the approach to managing wetlands should also be consistent with the *Environmental Protection (Swan Coastal Plain Lakes) Policy, 1992* (EPA, 1992) and the *Position Statement: Wetlands* (WRC, 2001).
2. There shall be no new constructed stormwater infrastructure within Conservation category wetlands and their buffers, or other conservation value wetlands and their buffers, or within a waterway foreshore area (e.g. no pipes or constructed channels within these wetlands and their buffers, or within waterway foreshore areas), unless authorised by the DoE or the Environmental Protection Authority. For Resource Enhancement and Multiple Use category wetlands, stormwater management shall be consistent with the objectives outlined in the *Position Statement:Wetlands* (WRC, 2001).
3. The creation of artificial lakes or permanent open water bodies generally will not be supported when they involve the artificial exposure of groundwater (e.g. through excavation, or lined lakes that require groundwater to maintain water levels in summer) or the modification of a wetland type (e.g. converting a dampland into a lake). Where water conservation (e.g. summer water supply) and environmental and health concerns (e.g. hydrology, water quality, mosquitoes, midges, algal blooms, acid sulfate soils and iron monosulfide minerals) can be adequately demonstrated to be addressed through design and maintenance, consideration may be given to the creation of artificial lakes/ponds. Seasonal wet infiltration areas or approved constructed waterways (i.e. ephemeral 'Living Streams') are preferred options.

Management of groundwater levels

1. Any proposals to control the seasonal or long-term maximum groundwater levels through a Controlled Groundwater Level (CGL) approach shall demonstrate through adequate field investigations, to the satisfaction of the Department of Environment, that local and regional environmental impacts are adequately managed.
2. The CGL may be defined as the controlled (i.e. modified) groundwater level (measured in metres Australian Height Datum) at which the DoE will permit drainage inverts to be set. The CGL must be based on local and regional environmental water requirements, determined in accordance with the *Environmental Water Provisions Policy for Western Australia* (WRC, 2000) and the *Urban Development and Determination of Ecological Water Requirements of Groundwater Dependent Ecosystems* (DoE, in preparation).
3. Where appropriate, field investigations must be undertaken to identify acid sulfate soils (ASS). Any reduction in groundwater level should not expose ASS to the air, as this may cause groundwater contamination. Refer to the ASS Guideline Series, including *Identification and Investigation of Acid Sulfate Soils* (DoE, 2004). If field investigations identify ASS, seek further advice from DoE.

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Department of Environment

SWAN RIVER TRUST

Swan-Canning Cleanup Program

APPENDIX C

Birrega Main Drain Realignment Report (JDA, 2008)

SPM Project Marketing

Lots 1 & 2 Rowley Road
Darling Downs

Assessment of Birrega Main Drain Realignment

July 2008

JDA Consultant Hydrologists

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1. INTRODUCTION

1.1 Background

Lots 1 & 2 Rowley Road (herein referred to as the Study Area) are located in Darling Downs approximately 30km southeast of the Perth Central Business District in the Shire of Serpentine Jarrahdale. The Study Area is bound to the south by Rowley Road and is approximately 11ha in size (Figure 1).

The Birrega Main Drain (BMD) flows beneath Rowley Road in a northerly direction and changes course midway through the Study Area, flowing west under Hopkinson Rd and continuing west to Tonkin Highway. Figure 1 shows the Study Area and BMDs existing route.

The BMD is an unfenced steep sided excavated trapezoidal drain, without any riparian vegetation and has no designated drainage easement in the Study Area.

SPM Marketing appointed JDA Consultant Hydrologists to conduct an investigation of the potential realignment of the BMD to accommodate proposed residential development within the Study Area. The scope of works undertaken included calculating the 100 year average recurrence interval (ARI) flow of the BMD, a field investigation to inspect the condition and current alignment of the drain, and develop a HECRAS backwater model to assess the effect of realigning the drain on its hydraulic performance.

This report summarises the outcomes of this investigation.

1.2 Planning Context

BMD is located within the Mundijong Rural Drainage District and is a rural drain maintained by the Water Corporation. It joins the Serpentine River and ultimately discharges to the Peel-Harvey Estuary. Review of existing historical maps and available aerial photographs indicate the drain in its current alignment would have been constructed after 1925 and prior to 1953.

In terms of level of service, for rural drains the Water Corporation generally apply a three day inundation rule for adjacent rural land. In this respect BMD is currently not maintained for any specific flood frequency, such as a 10 or 100 year average recurrence interval (ARI) event which would be the case for an urban drain. There is therefore no existing 100 year ARI floodplain mapping of the BMD.

Discussions with both the Water Corporation and Department of Water (DoW) have indicated no overarching drainage planning currently exists or is planned to be undertaken for BMD in the foreseeable future.

The Armadale Redevelopment Authority (ARA) has recently completed preparation of the Wungong Urban Water (WUW) Master Plan for the redevelopment of the Brookdale area. The Study Area is bound on its north and west borders by the WUW Master Plan area. As part of the Master Plan, a District Water Management Strategy (DWMS) was prepared, proposing BMD be realigned downstream of Hopkinson Road. The realignment was proposed to assist in achieving planning outcomes and in particular environmental objectives through linking the BMD to areas of significant vegetation protection, while also improving the existing hydraulic performance of the BMD.

The alignment of BMD in the Master Plan is shown in Figure 2. Both Water Corporation and DoW were representatives on the steering committee overseeing the development of the DWMS.

The proposed realignment of the BMD presented in this report is consistent with the WUW Master Plan and the DWMS and effectively represents the first stage of its proposed realignment from the Study Area to Tonkin Highway (Figure 2).

Currently, urban development of the adjacent Precinct K is being under taken by Peet and Co. The Local Structure Plan in presented in Figure 3. The alignment of the BMD is consistent with that proposed in the DWMS and is within a 50m buffer.

While no current arterial drainage planning existing or is proposed by either Water Corporation or the Department of Water (DoW), discussions with DoW have indicated the realignment of BMD would be considered subject to sufficient technical analysis being undertaken to demonstrate realignment would not adversely affect flood levels or flood risk for adjacent properties.

This analysis is presented in this report.

2. FIELD INVESTIGATION

2.1 Site Visit

On 8 September 2006, JDA conducted a site visit during which channel conditions were noted in BMD.

General drain conditions were also observed as an indication of the Manning's n roughness coefficient to be used for hydraulic modelling and design flood level estimation purposes.

Within the Study Area, the main channel is characterised by short grasses and an excavated meandering channel. The floodplain of BMD largely consists of grazing pasture for stock.

There is no significant riparian vegetation present. Downstream of the Study Area the channel has similar conditions.

Photographs taken during this field visit are presented in Appendix A.

2.2 BMD & Culvert Survey

In April 2007, Whelans Survey and Mapping surveyed 10 cross-sections (XS1 to XS10) of BMD from immediately downstream of Tonkin Highway (XS1) to upstream of Rowley Road (XS10), over a total distance of approximately 1400m.

Locations of surveyed cross sections are shown in Figure 4.

All culverts and road heights within this area were also surveyed.

3. ESTIMATION OF DESIGN FLOWS

No 100 year ARI design flow estimates for BMD were available from Water Corporation or DoW.

The catchment area for BMD is shown in Figure 5. This and is approximately 350 ha to the upstream boundary of the Study Area. The catchment boundary was based on existing available topographic data and the location and flow direction of known drains.

In addition to its local catchment, Birrega Main Drain also receives flow from Wungong River.

The Wungong Urban Water Master Plan District Water Management Strategy (JDA, CSIRO & GHD, 2006) describes that the Wungong River is partially diverted into BMD due to the backwater effect of an existing weir on Wungong River immediately downstream of the Wungong River / BMD confluence.

Previous studies have indicated that up to 30% of flow is diverted into BMD from Wungong River (JDA, CSIRO & GHD, 2006). The catchment area for Wungong River at South West Highway is 1360 ha (JDA, CSIRO & GHD, 2006). Therefore for estimation of design flows, the total contributing catchment to the Study Area (including the partial catchment from Wungong River) can be approximated as 750 ha. JDA (2005) reported an estimated 100 year flow at the Birrega Main drain offtake of 17.2 m^3/s. The 100 year contribution to Birrega Main Drain can there be estimated as approximately 5.2 m^3/s.

Based on rating flows for other known rivers and drains in the area against contributing catchment area (Figure 6), the estimated 100 year ARI flow for BMD is 8 m^3/s. Confidence in this 100 year estimate for use in design is provided via the following checks :

- Use of the Rational Method (Institution of Engineers Australia, 2001) provides 2, 10 and 50 year ARI flood estimates for BMD's 350 ha catchment of 0.9, 1.5 and 2.5 m^3/s respectively. Extrapolation of these results, provides a 100 year flow estimate of 2.8 m^3/s. Addition of the potential diversion flow from Wungong River, provides a total combined estimated flows for BMD to the Study Area of 8 m^3/s. This is consistent with the rating curve estimate shown in Figure 6. Rational Method calculations are detailed in Appendix B.

- The 8 m^3/s 100 year estimate equates to a rated flow of approximately 11 l/s/ha. This shows good consistency with JDA, CSIRO & GHD (2006), in which the Water Corporation provided general design advice of a 100 year rated flow for BMD in the order of 12 l/s/ha.

- Based on the hydraulic model as detailed in Section 4, the capacity of the BMD at the Study Area is estimated to be approximately 2 m^3/s. This equates to approximately a 2 year ARI flow capacity for the existing drain. Based on informal discussions with the Water Corporation it is understood applying a three day inundation rule in design typically results in a drain capacity (without overtopping) of 2-3 year ARI. The current BMD capacity based on estimated design flows is consistent with the expected design capacity based on the 3 day inundation rule, given additional confidence in design flow estimates.

A 100 year ARI design flow of 8 m^3/s has therefore been adopted for analysis in this study.

4. ASSESSMENT OF BMD REALIGNMENT

4.1 HECRAS Model & Parameters

A HECRAS backwater model of the BMD extending approximately 1400m from the upstream boundary of the Study Area to the culverts under Tonkin Highway was developed based on surveyed cross-sections provided by Whelans Survey and Mapping.

Based on field observations a Manning's n roughness coefficient of 0.03 was used in this study (Appendix A). This is consistent with Water Authority floodplain mapping in similar studies for adjacent catchments such as Wungong Brook Floodplain Mapping (WAWA, 1989).

A backwater condition was set for XS1 (Figure 4) at 25.2 mAHD, representative of bankfull flow. This assumption has negligible effect on modelled flood levels at Study Area.

4.2 Modelled Scenarios

Five scenarios were modelled as part of this study and are detailed in Table 1 below. The various scenarios aim to represent likely stages of the upgrading of the BMD toward the proposed realignment shown in the WUW Masterplan, and to assess the impact not only of the drain realignment, but the impact of the development (and filling) of Lots 1 and 2 Rowley Rd on existing flood levels.

For all modelled scenarios, cross sections XS1 and XS10 remain unchanged and as existing, including Tonkin Highway and its existing culverts. Sections XS2 to XS9 were modified to represent changes to the location and cross section of the drain a result of realignment.

TABLE 1: HECRAS MODELLING SCENARIOS

Scenario	Description
1. Existing BMD	• Existing alignment and capacity of BMD • Existing floodplain levels • Existing culverts maintained
2. Realignment of BMD	• Proposed Stage 1 re-alignment of BMD (Figure 2) consistent with WUW Masterplan proposed realignment • Existing floodplain levels • Existing culverts maintained
3. Realignment of BMD & Development of Lots 1&2	• Proposed Stage 1 re-alignment of BMD (Figure 2) • Filling of floodplain in Lots 1 & 2 for development • Existing culverts maintained
4. Realignment of BMD & Development of Lots 1&2 and adjacent Precinct K & Upgraded Culverts	• Proposed Stage 1 re-alignment of BMD (Figure 2) • Filling of floodplain for development • Upgraded culverts under Hopkinson Road
5. Ultimate Realignment of BMD & Development of Lots 1 2 and adjacent Precinct K & Upgraded Culverts	• Ultimate re-alignment of BMD (Figure 2) • Filling of floodplain in for development • Upgraded culverts under Hopkinson Road • Upgraded culverts under Rowley Road

4.3 Modelling Results

Modelling results for the scenarios described in Table 1 are summarised in Table 2 and shown as cross sections in Appendix C. Figures 7 shows the long section of BMD for all scenarios modelled with a 100 year peak flow of 8 m^3/s.

Summarising the modelling results:

- Modelling of the existing drain (Scenario 1) indicates the existing culverts under Hopkinson Rd and Rowley Rd do not have adequate capacity to convey the 100 year storm event, and overtopping of both roads these roads will occur in a 100 year event.

- Downstream of Hopkinson Road the 100 year ARI flow is able to be contained within the existing main channel of BMD (Appendix C, Figure C1). Note culverts at Tonkin Highway have adequate capacity to convey the 100 year flow, with a freeboard of approximately 0.8m to the Highway surface for the 100 year storm event.

- Realignment of BMD (Scenario 2, Appendix C Figure C2) does not result in any change of flood levels either upstream of downstream of the Study Area. The realigned drain was modelled with similar invert and 1:6 side slopes, resulting in an increased hydraulic capacity compared to the existing drain. While some minor changes to flood levels within the Study Area were observed, in all cases the 100 year flood level for these cross sections was contained within the realigned channel.

- Filling of the Study Area (Scenario 3, Appendix C Figure C3) results in minor flood level increases within the Study Area of up to 0.05m only (XS 8) compared to Scenario 2. All flows were maintained within the realigned channel and similarly to Scenario 2 the filling did not impact flood levels upstream or downstream of the Study Area.

- To remove flooding of Hopkinson Rd adjacent to the Study Area (Scenario 4, Appendix C, Figure C4) upgrading the culvert capacity under Hopkinson Rd to five 1 050mm diameter culverts was found to be required immediately downstream of the Study Area. Similarly, upgrading of culverts at the entry point of the BMD to the Study Area could also be undertaken to maintain 100 year flood levels below the existing road level at this location. Filling of the floodplain both within the Study Area and downstream Precinct K has also been modelled and has had negligible effect on the flood levels.

- Upgrading of the culvert under Rowley Rd (Scenario 5, Appendix C, Figure C5) to four 900 mm diameter culverts was found to reduce the 100 year ARI flood level by up to 0.4 m upstream of the Study Area. In addition, realignment of the BMD downstream of the Study Area consistent with the WUW Masterplan would provide further opportunities for improving the hydraulic performance of the system. Filling of the floodplain both within the Study Area and downstream Precinct K has also been modelled and has had negligible effect on the flood levels.

In summary, the results of this modelling demonstrate realignment of the BMD and filling of land for development within Lots 1 and 2 Rowley Rd can be undertaken without adversely affecting flood levels either upstream or downstream of the Study Area.

TABLE 2: ESTIMATED 100 YEAR ARI FLOOD LEVELS

Cross Section	**100 Year Flood Levels (mAHD)**				
	Scenario 1 Existing BMD	**Scenario 2** Realignment of BMD	**Scenario 3** Realignment of BMD Develop Lots 1 & 2	**Scenario 4** Realignment of BMD Develop Lots 1 & 2 Upgrade Culverts	**Scenario 5** Ultimate Realignment of BMD and Upgrade of Culverts
XS1	25.20	25.20	25.20	25.20	25.20
XS2	25.44	25.44	25.44	25.44	25.44
XS3	25.42	25.42	25.42	25.42	25.42
XS4	25.60	25.60	25.60	25.60	25.60
XS5	25.72	25.72	25.72	25.72	25.72
XS6	25.99	25.99	25.99	25.97	25.97
XS7	26.52	26.52	26.54	26.10	26.10
XS8	26.39	26.49	26.54	26.42	26.40
XS9	26.75	26.65	26.60	26.77	26.60
XS10	27.14	27.14	27.14	27.14	26.74

5. CONCLUSIONS/RECOMMENDATIONS

- BMD is located within the Mundijong Rural Drainage District and is a rural drain maintained by the Water Corporation. Within the Study Area, it is an unfenced steep sided excavated trapezoidal drain, without any riparian vegetation and has no designated drainage easement. Review of existing historical maps and available aerial photographs indicate the drain in its current alignment would have been constructed after 1925 and prior to 1953.

- In terms of level of service, for rural drains the Water Corporation generally apply a three day inundation rule for adjacent rural land. In this respect BMD is currently not maintained for any specific flood frequency. The hydraulic assessment of the existing drain capacity (including culverts) during this study has indicated its capacity is approximately 1 in 2 year ARI.

- Realignment of the BMD was proposed in the WUW Master Plan to assist in achieving planning outcomes and in particular environmental objectives through linking the BMD to areas of significant vegetation protection, while also improving the existing hydraulic performance of the BMD. The proposed realignment in the Study Area is consistent with the WUW Master Plan and represents the first stage of its realignment to Tonkin Highway.

- Discussions with both the Water Corporation and Department of Water (DoW) have indicated no overarching drainage planning currently exists or is planned to be undertaken for BMD or its proposed realignment in the foreseeable future.

- No 100 year ARI design flow estimates for BMD were available from Water Corporation or DoW. Based on rating flows for other known rivers and drains in the area against contributing catchment area, the estimated 100 year ARI flow for BMD is 8 m^3/s.

- A HECRAS backwater model of the BMD extending approximately 1400m from the upstream boundary of the Study Area to the culverts under Tonkin Highway was developed. Modelling of the existing drain indicates the existing culverts under Hopkinson Road and Rowley Road do not have adequate capacity to convey the 100 year storm event, and overtopping of both roads occurs.

- Realignment of the BMD in the Study Area will not result in any change of flood levels either upstream of downstream of the Study Area. While some minor changes to flood levels within the Study Area were observed, in all cases the 100 year flood level for these cross sections was contained within the realigned channel.

- Filling of the Study Area resulted in minor flood level increases within the Study Area of up to 0.05m, however all flows were maintained within the realigned channel and the filling did not impact flood levels upstream or downstream of the Study Area.

- To remove flooding of Hopkinson Road upgrading the culvert capacity to five 1050mm diameter culverts was found to be required immediately downstream of the Study Area. Similarly, upgrading of culverts at the entry point of the BMD to the Study Area could also be undertaken to maintain 100 year flood levels below the existing road level at this location.

- The results of this modelling demonstrate realignment of the BMD and filling of land for development within Lots 1 and 2 Rowley Road can be undertaken without adversely affecting flood levels either upstream or downstream of the Study Area.

- Future realignment of the BMD downstream of the Study Are consistent with the WUW Masterplan would provide further opportunities for improving the hydraulic performance of the system.

6. REFERENCES

Institution of Engineers (2001) Australian Rainfall & Runoff – a Guide to Flood Estimation Volumes 1 & 2. Editor Pilgrim, D.H.

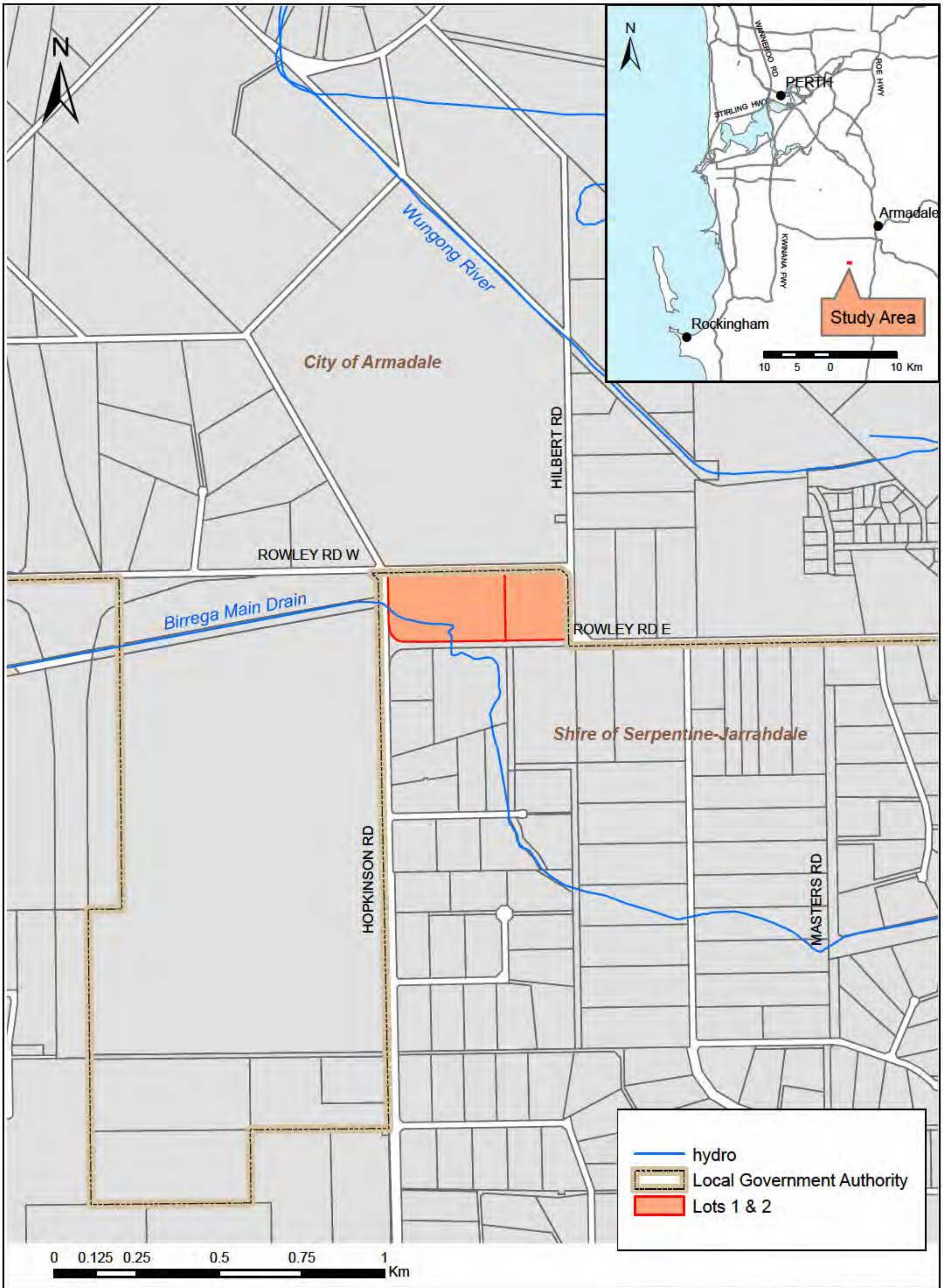
JDA Consultant Hydrologists (2003) Southern River and Wungong Brook Floodplain Mapping Review, Hydrology report for Armadale Redevelopment Authority

JDA Consultant Hydrologists (2005), Southern River and Wungong Brook Floodplain Mapping Review, Hydrology, report for Armadale Redevelopment Authority, February 2005.

JDA, CSIRO, and GHD (2006), Wungong Urban Water Master Plan District Water Management Strategy. Armadale Redevelopment Authority

Water Authority WA (1989), Wungong Brook Flood Plain Mapping

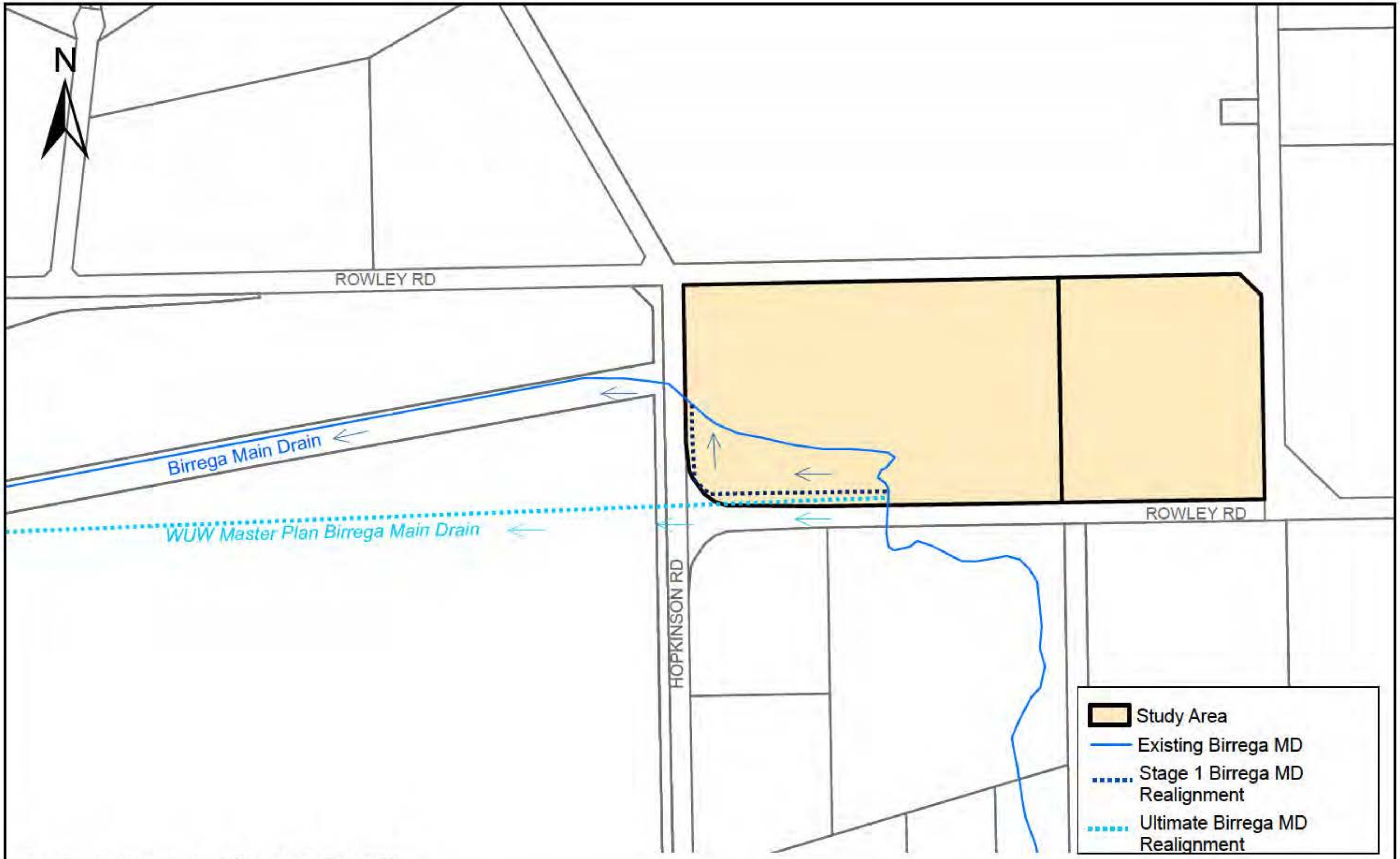
FIGURES



JDA Consultant Hydrologists

Job No: J3661
Scale 1:15,000

SPM Project Marketing
Lots 1 & 2, Rowley Road, Darling Downs: Birrega Drain Realignment
Figure 1: Location Plan



Data Source: Wungong Urban Water Master Plan (2006)

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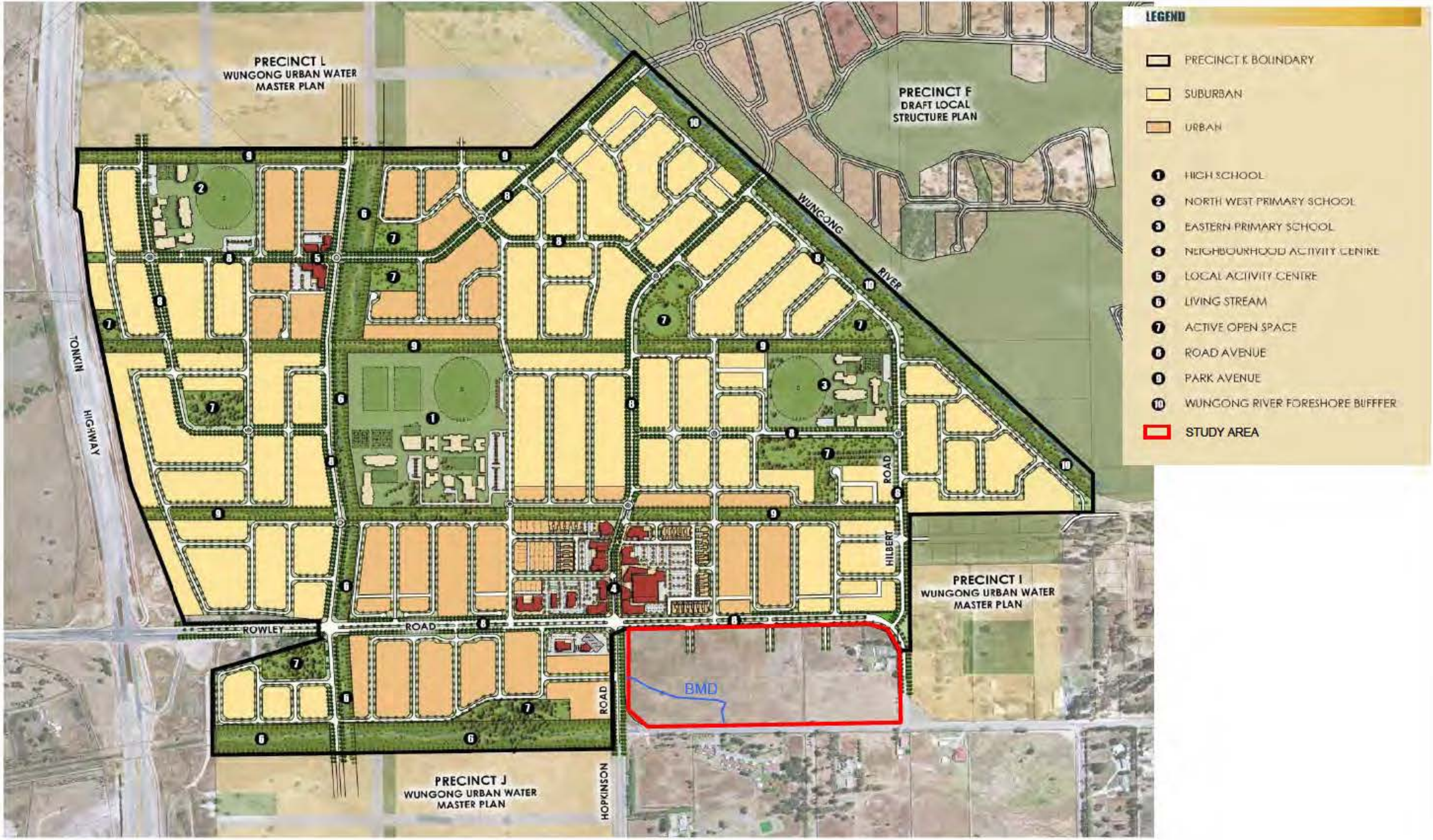
Job No. J3661
Scale: 1:5,000

Deneva Pty Ltd
Lot 1 &2 Rowley Rd, Darling Downs: Birrega Drain Realignment
Figure 2: Proposed Staging of Birrega Main Drain Realignment



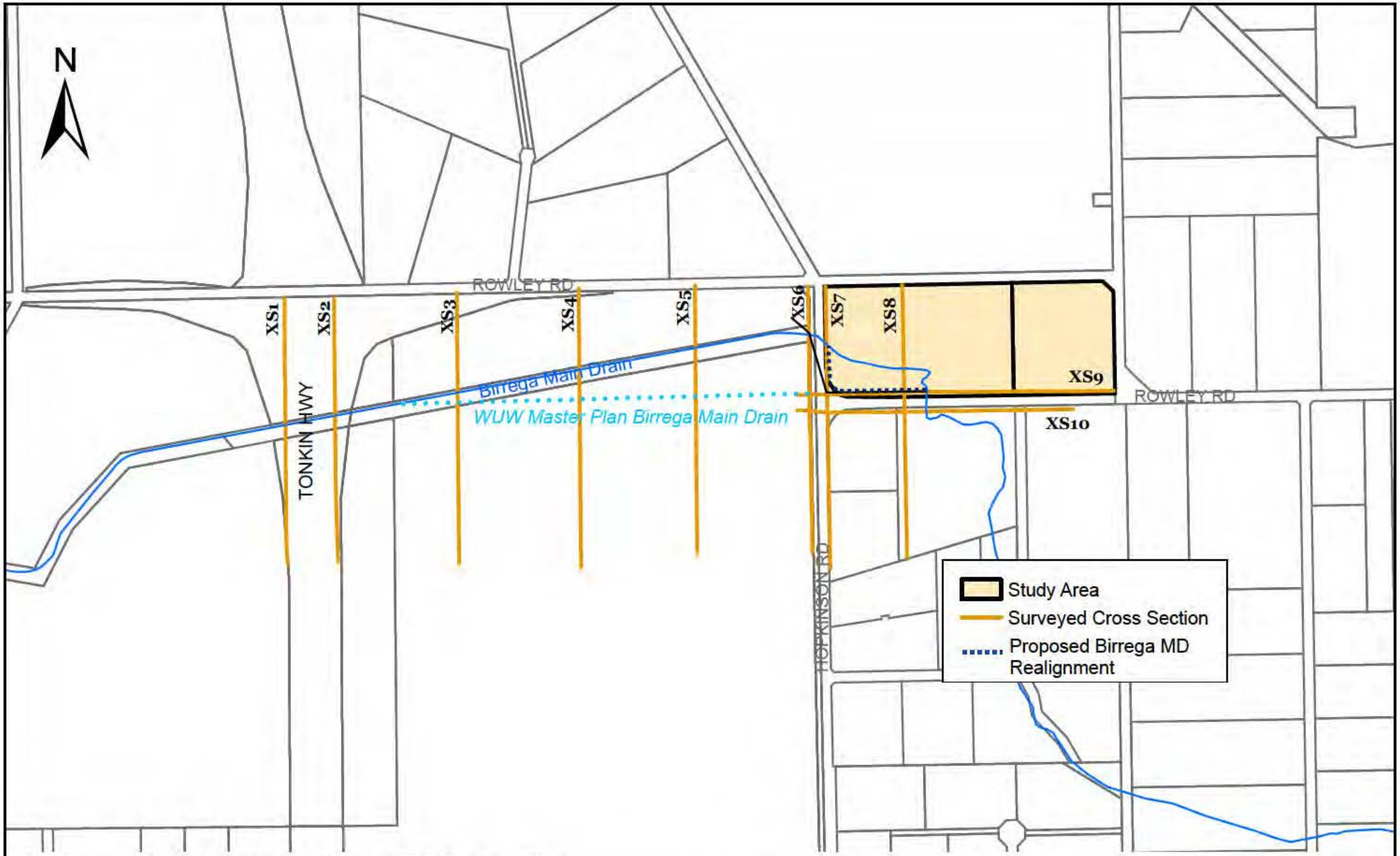
Data Source: Precinct K Local Structure Plan (Taylor Burrell Barnet, 2008)

JDA Consultant Hydrologists

Job No. J3661
Not to Scale

N

SPM Project Marketing
Lots 1 & 2 Rowley, Darling Downs: Birrega Drain Realignment
Figure 3: Adjacent Precinct K Local Structure Plan



Data Source: Whelans Survey (2006), Wungong Urban Water Master Plan (2006)

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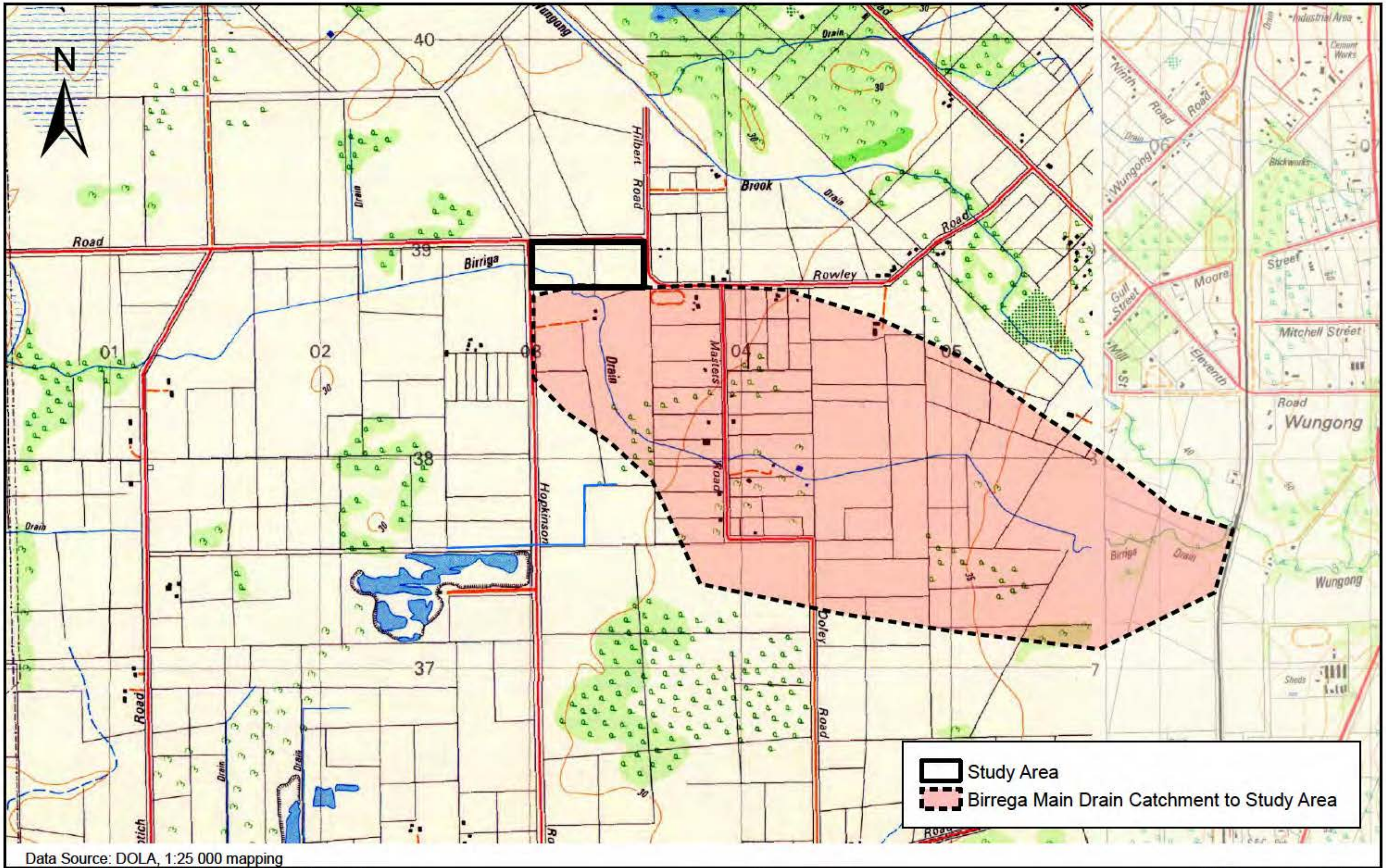
Job No. J3661
Scale: 1:10,000

Deneva Pty Ltd
Lot 1 &2 Rowley Rd, Darling Downs: Birrega Drain Realignment
Figure 4: Cross Section Locations

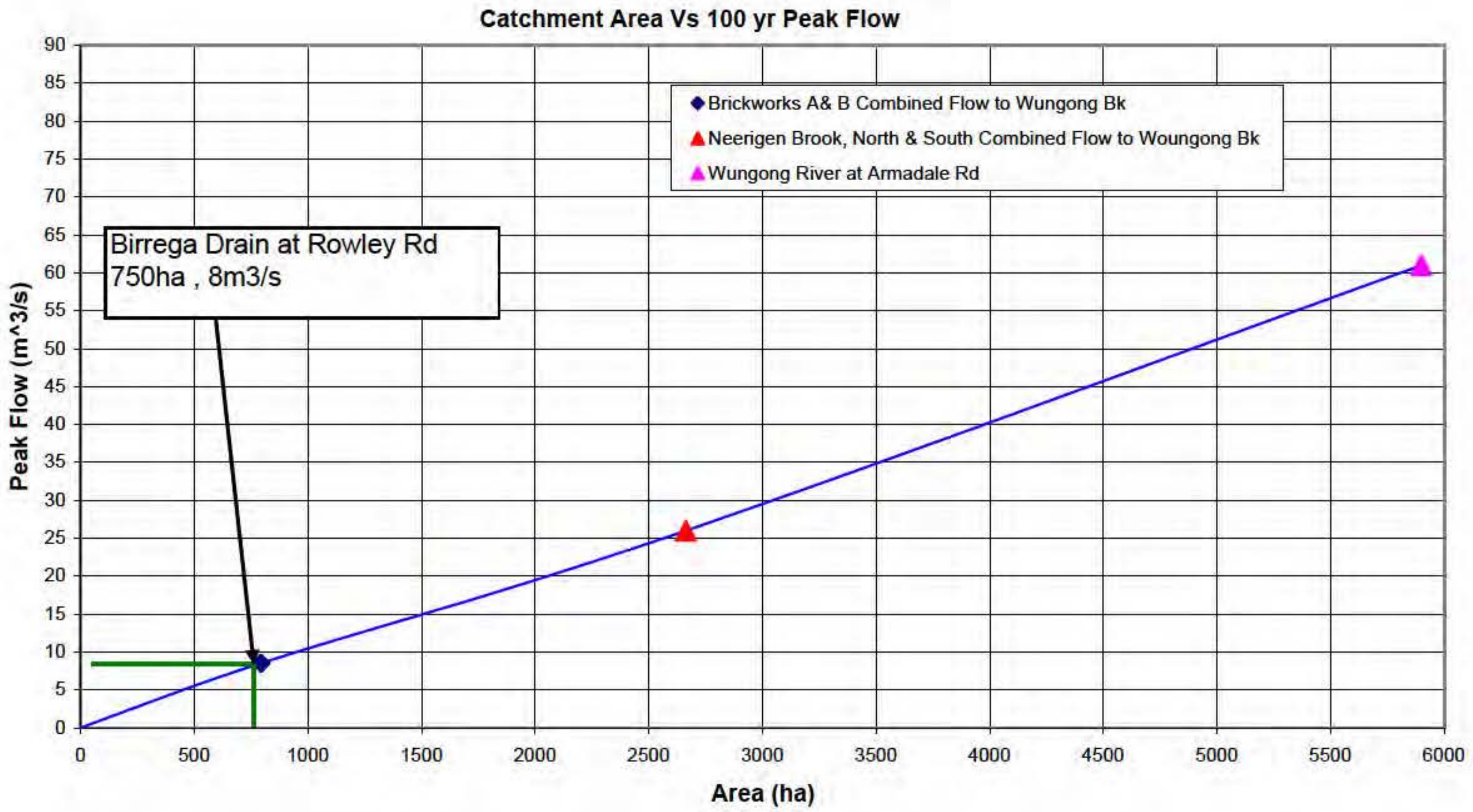


Data Source: DOLA, 1:25 000 mapping

Consultant Hydrologists

Job No. J3661
Scale: 1:25,000
0 200 400 600 800 Meters

SPM Project Marketing
Lots 1 & 2 Rowley Rd, Darling Downs: Birrega Drain Realignment
Figure 5: Catchment Plan



Catchment Area Vs 100 yr Peak Flow

Data Source: JDA, 2003 and WAWA, 1989)Southern River and Wungong Brook Floodplain Mapping

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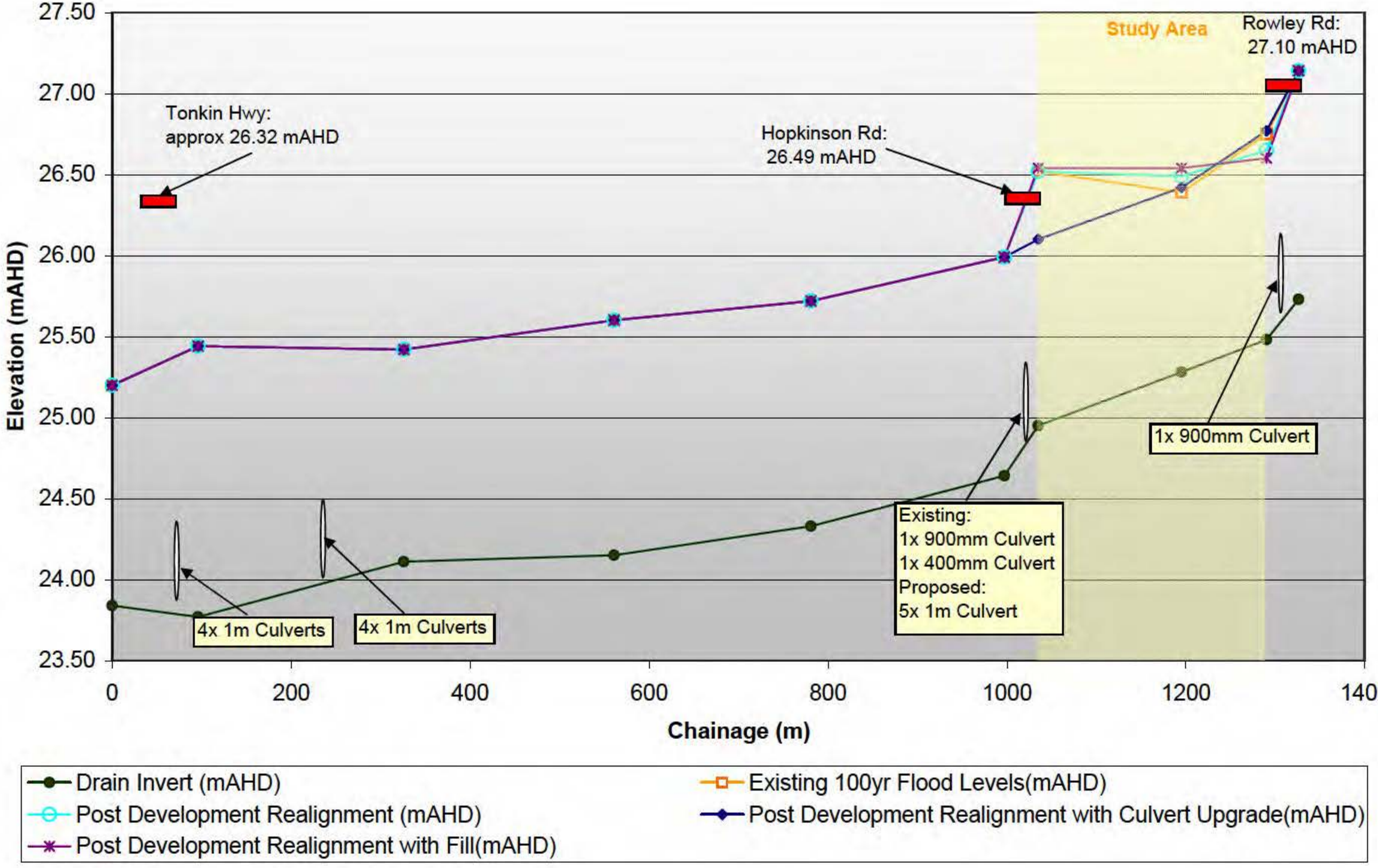
Lots 1& 2, Rowley Road, Darling Downs: Birrega Main Drain Realignment

Figure 6: Flow Analysis



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Lots 1 & 2 Rowley Rd, Darling Downs: Birrega Drain Realignment

Figure 7: Long Section of Birrega Main Drain

APPENDIX A

Site Photographs

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Lots 1 & 2 Rowley Rd, Darling Downs: Birrega Main Drain Realignment

Figure A1: Birrega Main Drain within Study Area

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Lots 1 & 2 Rowley Rd, Darling Downs: Birrega Main Drain Realignment

Figure A2: Typical Section of Birrega Main Drain within Study Area

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Lots 1 & 2 Rowley Rd, Darling Downs: Birrega Main Drain Realignment

Figure A3: Birrega Main Drain within Study Area Looking Upstream of Outlet

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Lots 1 & 2 Rowley Rd: Birrega Drain Realignment

Figure A4: Birrega Main Drain within Study Area Looking Upstream from Hopkinson Rd

APPENDIX B

Rational Method Calculations

ESTIMATION OF PEAK FLOW RATES

Method from Australian Rainfall & Runoff - Volume 1 (1987).

JDA Consultant Hydrologists

SOUTH WEST REGION

Select appropriate catchment: Low jarrah forest with sandy soils ▼

User to enter

RATIONAL METHOD FOR THE SOUTH WEST

3

Catchment area	3.5	km^2
Mainstream length	4	km
Slope	3	m/km
Catchment cleared	90	%

C_{10} = 0.138 C10=3.12*10-2 *100.0043CL*(LSe)^0.24

t_c = 272.6 mins $tc=2.31A^{0.54}$

4.5 hours

ARI (yrs)	2	5	10	20	50	
C_y/C_{10}	0.80	0.90	1.00	1.11	1.22	
I_{tc} values	8.25	9.90	11.00	12.60	14.90	mm/hr ***(via IFD)***

$Q_y = 0.278\ C_{10}*(C_y/C_{10})\ I_{tc}\ A$	**Q =**	**0.88**	**1.20**	**1.48**	**1.87**	**2.45**	**m^3/s**

INDEX FLOOD METHOD FOR THE SOUTH WEST

Catchment area	5.1	km^2
Annual average precipitation	900	mm
Slope	3	m/km
Mainstream length	4	km
Catchment cleared	90	%

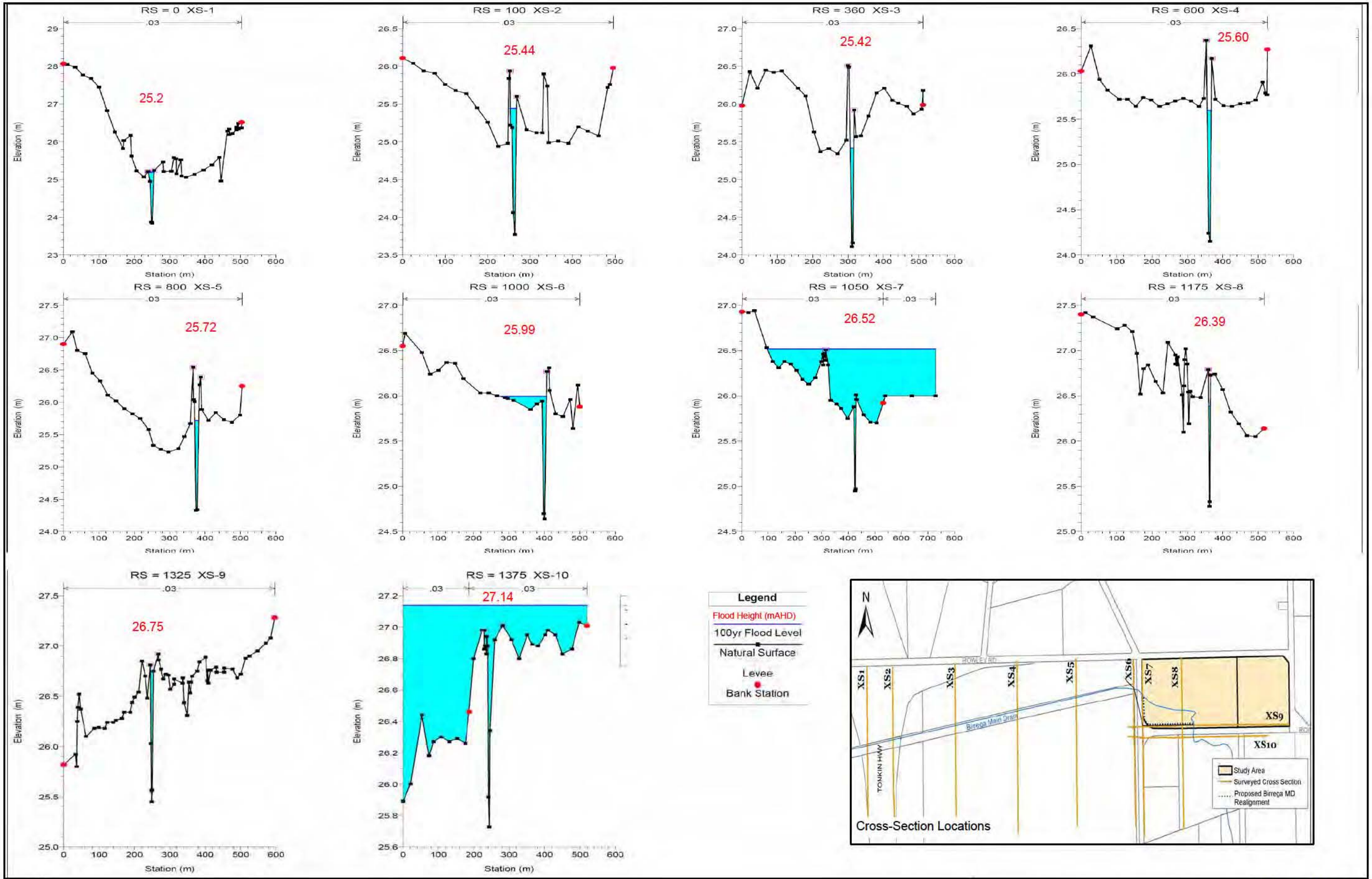
Q2 = 0.738 Q2 = 8.22*10-9 A0.73 P 2.22 (LSe)0.28 100.0064CL

ARI (yrs)	2	5	10	20	50
(Q_y/Q_2)	1.00	1.31	1.57	1.86	2.24

$Q_y = Q_2*(Q_y/Q_2)$	**Q =**	**0.74**	**0.97**	**1.16**	**1.37**	**1.65**	**m^3/s**

APPENDIX C

HEC-RAS Cross Section Modelling Results



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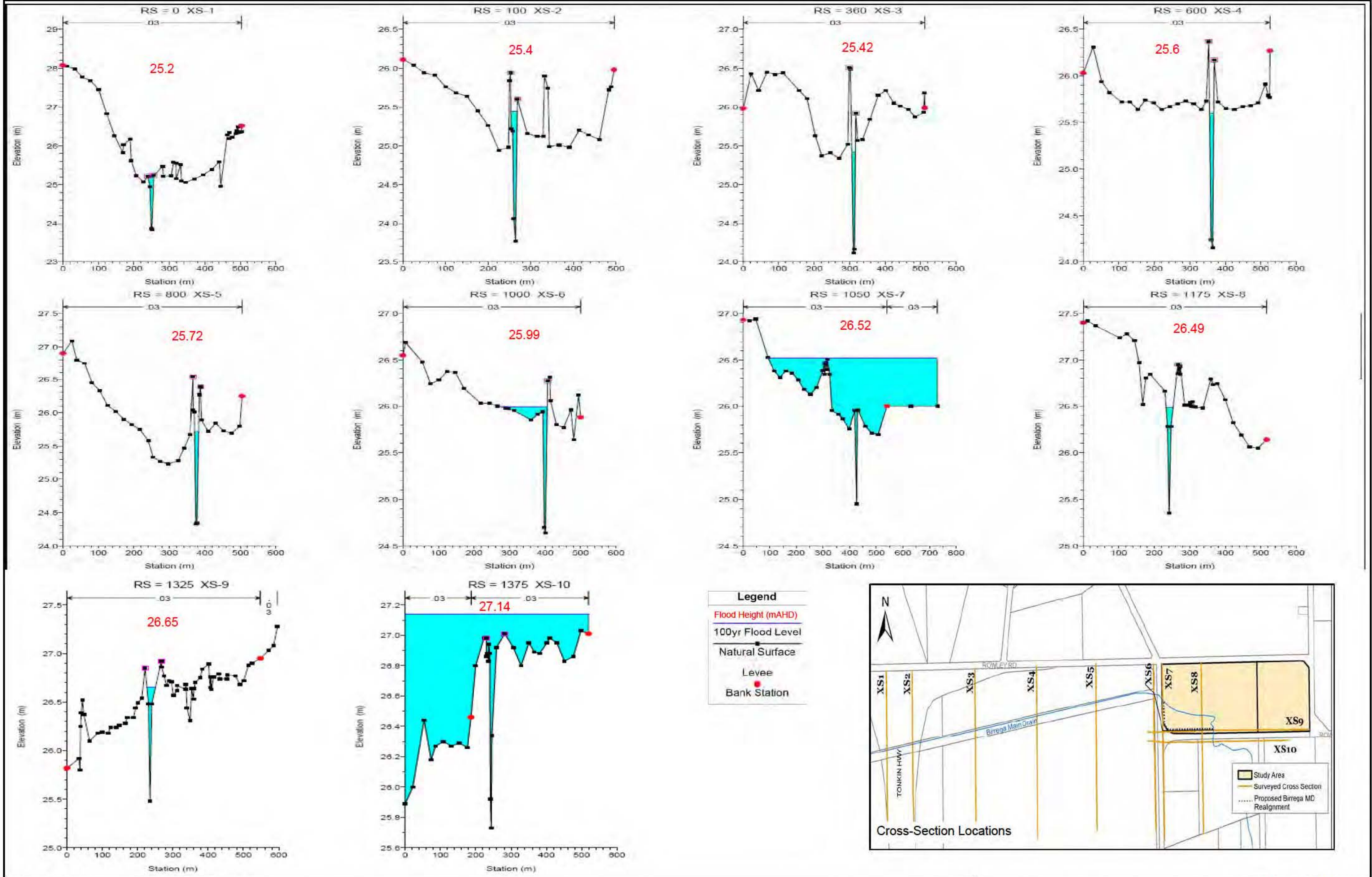
Lots 1 & 2 Rowley Rd, Darling Downs: Birrega Drain Realignment

Figure C1: Existing 100 Year ARI Flood Levels in Birrega Main Drain



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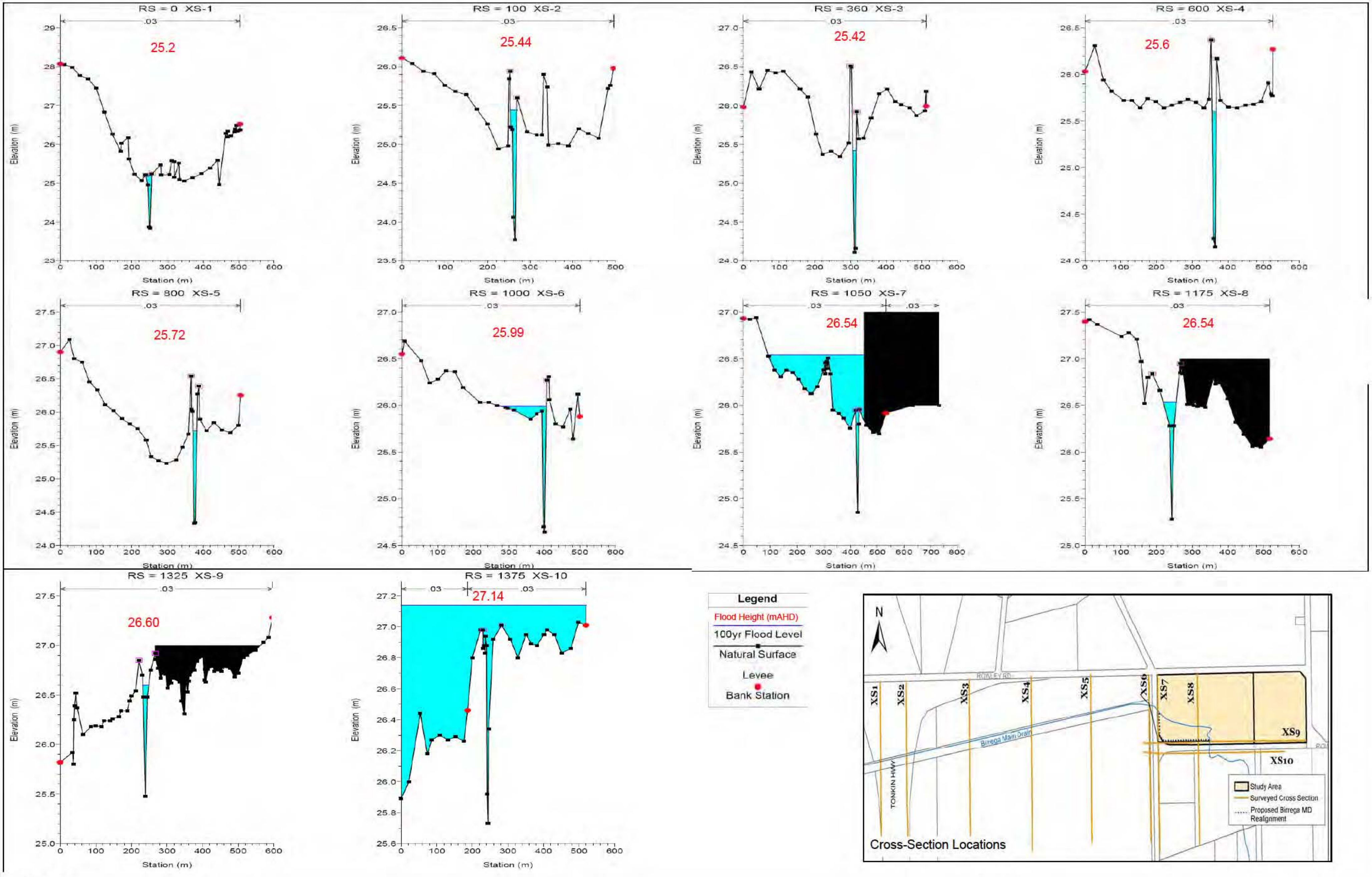
SPM Project Marketing
Lots 1 & 2 Rowley Rd, Darling Downs: Birrega Drain Realignment
Figure C2: Post Development 100 Year ARI Flood Levels in Realigned Birrega Main Drain



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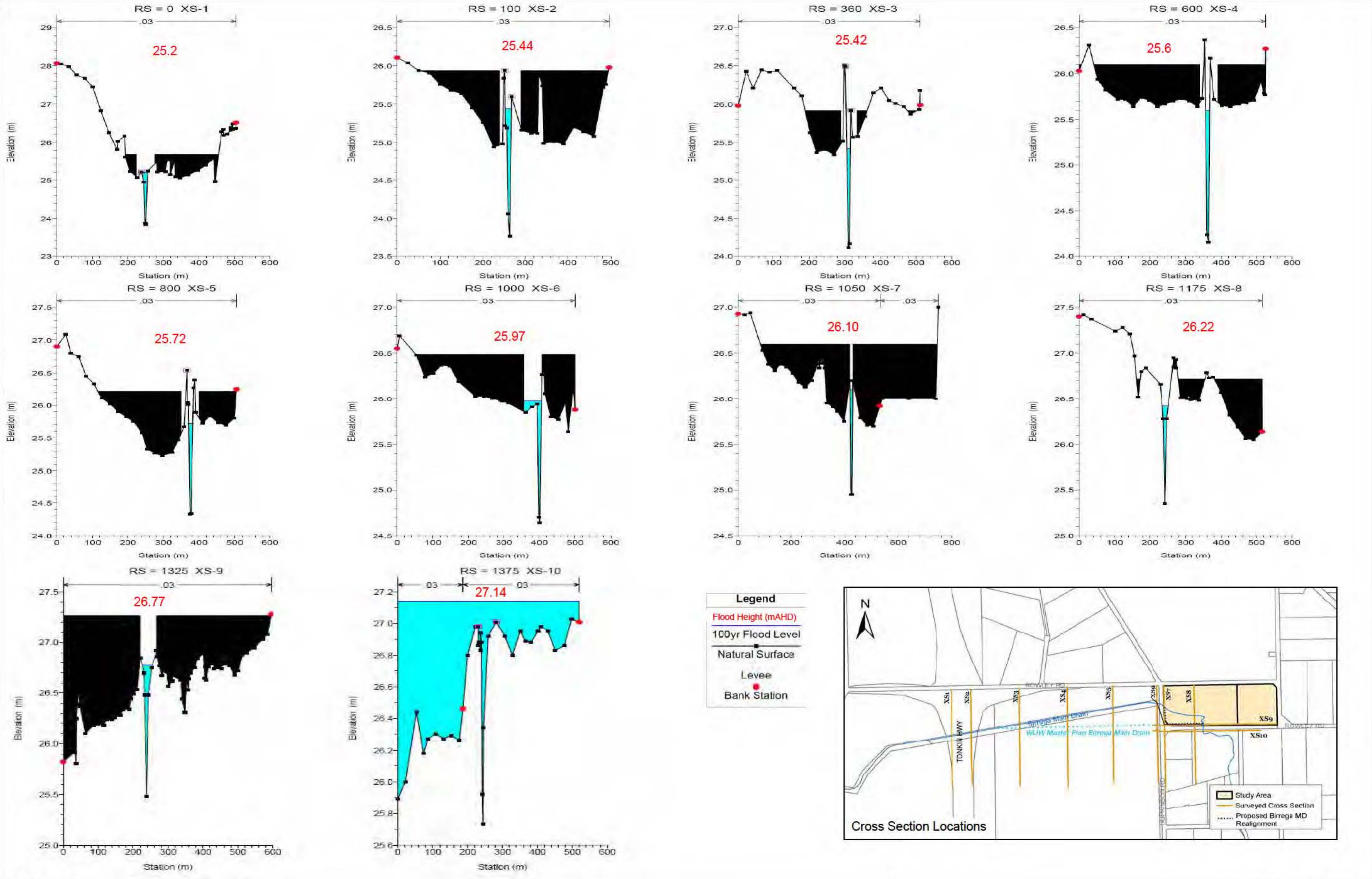
Job No. J3661

SPM Project Marketing

Lots 1 & 2 Rowley Rd, Darling Downs: Birrega Drain Realignment

Figure C3: Post Development 100 Year ARI Flood Levels in Realigned Birrega Main Drain with Filling of Floodplain



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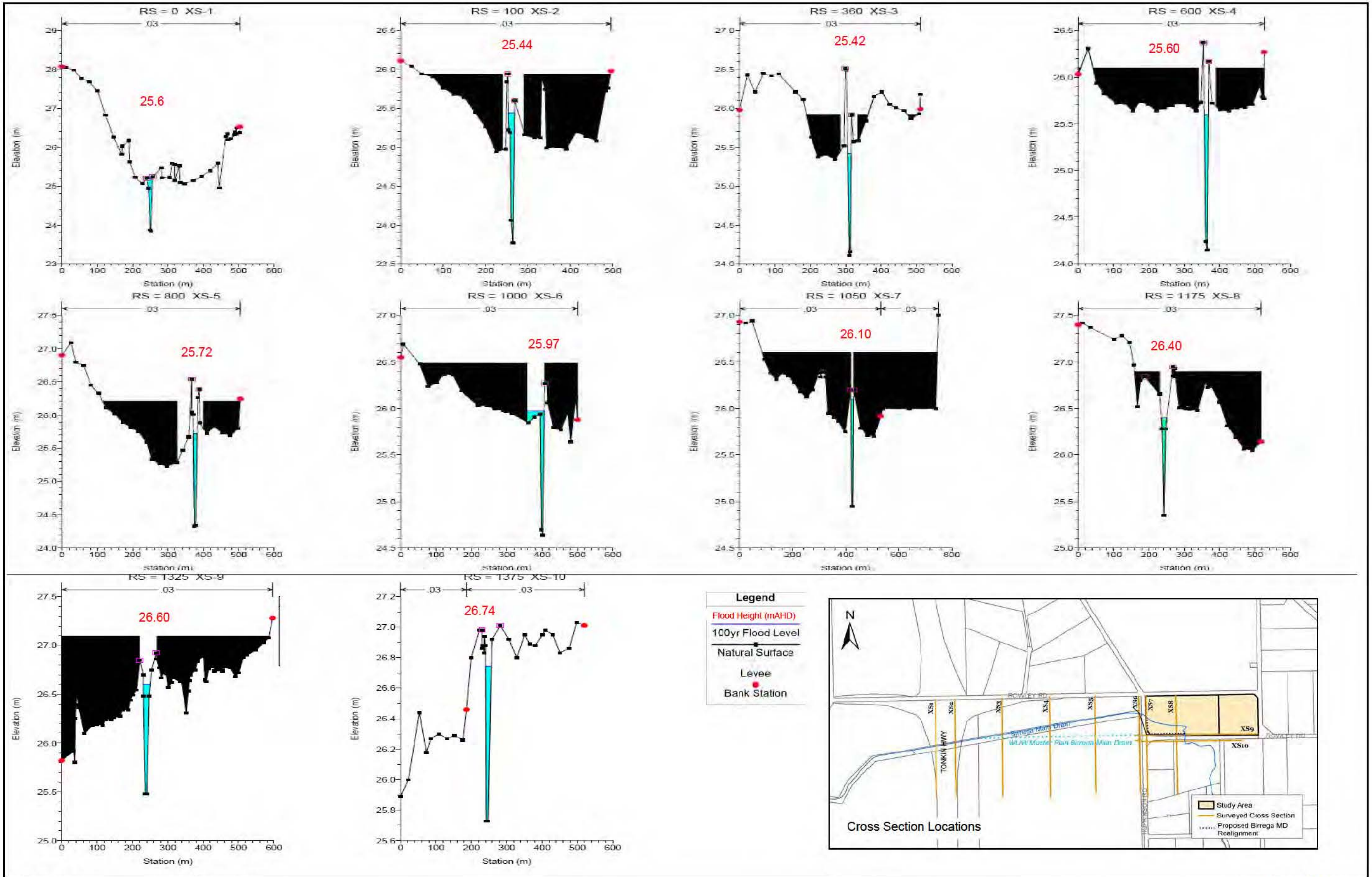
Lots 1 & 2 Rowley Rd, Darling Downs: Birrega Drain Realignment

Figure C4: Post Development 100 Year ARI Flood Levels in Realigned Birrega Main Drain with Upgraded Culverts under Hopkinson Rd



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Lots 1 & 2 Rowley Rd, Darling Downs: Birrega Drain Realignment
Figure C5: Post Development 100 Year ARI Flood Levels in Ultimate Realigned Birrega Main Drain with Upgraded Culverts under Hopkinson Rd and Rowley Rd

APPENDIX D

Department of Water Correspondence on JDA(2008)

Department of Water
Government of Western Australia

6

Your ref: J3361h
Our ref: Urban Drainage
Planning Advice and Assessment
Enquiries: Simone McCallum (6364 6623)

Sasha Martens
Jim Davies & Associates Pty Ltd
PO Box 117
Subiaco WA 6094

Dear Sasha,

Lots 1 & 2 Rowley Road, Darling Downs:
Assessment of Birrega Main Drain Realignment

The Department of Water has reviewed the proposal to realign the Birrega Main Drain within Lots 1 and 2 Rowley Road, Darling Downs. The Department supports the proposed Stage 1 re-alignment of the BMD (figure 2) subject to the following conditions:

- The culverts under Hopkinson Road are upgraded as modeled in Scenario 4 to prevent overtopping at the culvert in the 100 year ARI flood event.
- The realigned drain is constructed as specified in the HEC-RAS backwater model, with a similar invert to the existing drain and 1:6 side slopes.
- Sufficient land should be set aside to allow the construction of a shallow drain with gently sloping banks.
- The constructed banks should incorporate stabilisation measures to prevent erosion.

Yours sincerely

Peter Kata

Peter Kata
Senior Engineer, Urban Water Assessment
11 September 2008

168 St Georges Terrace Perth Western Australia 6000
PO Box K822 Perth Western Australia 6842
Telephone (08) 6364 7600 Facsimile (08) 6364 7601
www.water.wa.gov.au

APPENDIX E

Groundwater Bore Logs

JDA Consultant Hydrologists
Suite 1, 27 York Street
Subiaco WA 6008
Tel: 9388 2436
Fax: 9381 9279

JDA Consultant Hydrologists

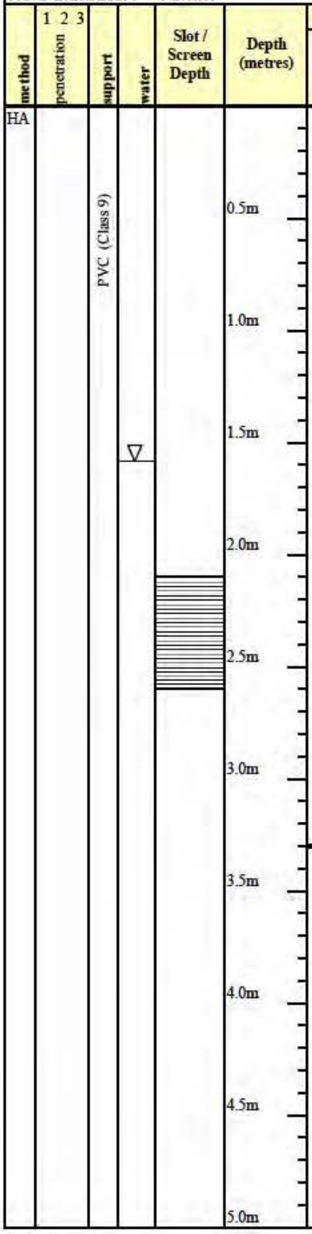
LITHOLOGICAL LOG

Client: SPM Projects Marketing
Project: Lots 1 & 2 Rowley Road, Darling Downs: LWMS
Bore location: 403160 E 6439183 N
Datum: MGA94/AHD

Job No: 4264
Hole commenced: 10 Sept 2008
Hole completed: 10 Sept 2008
Logged by: SS

Bore Name: RH1
Drill type: Hand Auger
Hole diameter: 75mm

Total Depth: 3.28 m
R.L. TOC: 26.549 mAHD
Natural Surface: 25.807 mAHD



SOIL CHARACTERISTICS

COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
Brown	Fine	Sandy Clay	Low	Moist	
		Clayey Sand		Saturated	Orange Mottle

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
Dark : Brown, Red, Orange, Yellow, Grey, Blue
Medium : Brown, Red, Orange, Yellow, Grey, Blue
Light : Brown, Red, Orange, Yellow, Grey, Blue
Tones : solid colour, blemish or mottle

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: ....

WL below TOC ....

Stickup above NS: ....m

WL .... m below NS

JDA Consultant Hydrologists
Suite 1, 27 York Street
Subiaco WA 6008
Tel: 9388 2436
Fax: 9381 9279

LITHOLOGICAL LOG

Client: SPM Projects Marketing
Project: Lots 1 & 2 Rowley Road, Darling Downs: LWMS
Bore location: 403163 E 6438987 N
Datum: MGA94/AHD

Job No: J4264
Hole commenced: 10 Sept 2008
Hole completed: 10 Sept 2008
Logged by: SS

Bore Name: RH2
Drill type: Hand Auger
Hole diameter: 75mm

Total Depth: 2.0 m
R.L. TOC: 27.319 mAHD
Natural Surface: 26.147 mAHD

method	penetration 1 2 3	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
HA		PVC (Class 9)				Brown	Fine	Sandy Clay	Low	Low	
					0.5m 1.0m	Grey		Clay			
			∇		1.5m	Red		Sandy Clay		Slightly Moist	Hard Layer
				▤	2.0m	Red/Brown	Medium	Clayey Sand			
											End of Hole
					2.5m						
					3.0m						
					3.5m						
					4.0m						
					4.5m						
					5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

		Tones : solid colour, blemish or mottle
Dark :	Brown, Red, Orange, Yellow, Grey, Blue	
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: ....

WL below TOC ....

Stickup above NS: ....m

WL .... m below NS

JDA Consultant Hydrologists
JDA Consultant Hydrologists
Suite 1, 27 York Street
Subiaco WA 6008
Tel: 9388 2436
Fax: 9381 9279

LITHOLOGICAL LOG

Client: SPM Projects Marketing
Project: Lots 1 & 2 Rowley Road, Darling Downs: LWMS
Bore location: 403670 E 6439192 N
Datum: MGA94/AHD

Job No: J4264
Hole commenced: 10 Sept 2008
Hole completed: 10 Sept 2008
Logged by: SS

Bore Name: RH3
Drill type: Hand Auger
Hole diameter: 75mm

Total Depth: 1.34 m
R.L. TOC: 27.333 mAHD
Natural Surface: 26.85 mAHD

	1 2 3					SOIL CHARACTERISTICS					
method	penetration	support	water	Slot / Screen Depth	Depth (metres)	COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
HA		PVC (Class 9)				Brown	Fine	Clayey Sand	Low	Moist	
			∇		0.5m		Medium	Sand		Saturated	
				▤	1.0m	Hard Layer					
						End of Hole					
					1.5m						
					2.0m						
					2.5m						
					3.0m						
					3.5m						
					4.0m						
					4.5m						
					5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown, Red, Orange, Yellow, Grey, Blue
Medium :	Brown, Red, Orange, Yellow, Grey, Blue
Light :	Brown, Red, Orange, Yellow, Grey, Blue

Tones : solid colour, blemish or mottle

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: ....

WL below TOC ....

Stickup above NS: ....m

WL .... m below NS

JDA Consultant Hydrologists
Suite 1, 27 York Street
Subiaco WA 6008
Tel: 9388 2436
Fax: 9381 9279

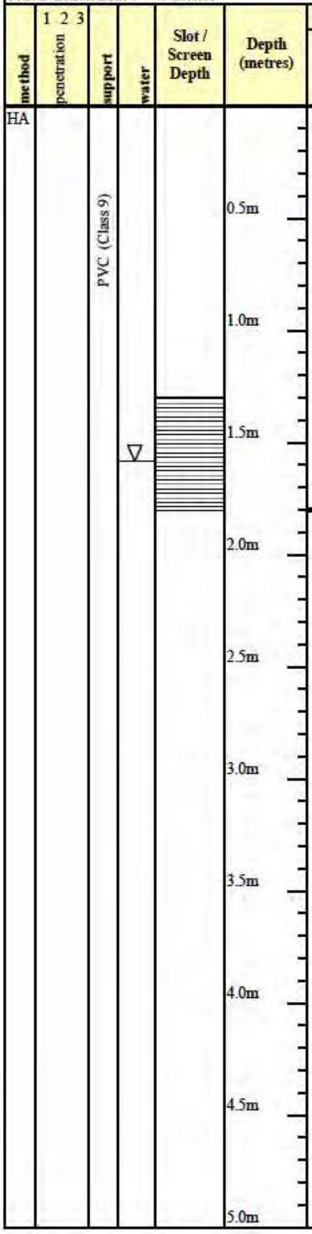
LITHOLOGICAL LOG

Client: SPM Projects Marketing
Project: Lots 1 & 2 Rowley Road, Darling Downs: LWMS
Bore location: 403685 E 6438989 N
Datum: MGA94/AHD

Job No: J4264
Hole commenced: 10 Sept 2008
Hole completed: 10 Sept 2008
Logged by: SS

Bore Name: RH4
Drill type: Hand Auger
Hole diameter: 75mm

Total Depth: 1.82 m
R.L. TOC: 27.175 mAHD
Natural Surface: 27.208 mAHD



SOIL CHARACTERISTICS

COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
Brown	Medium	Sand	Nil	Slightly Moist	
				Saturated	
		Clayey Sand			
					End of Hole

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
Dark : Brown, Red, Orange, Yellow, Grey, Blue
Medium : Brown, Red, Orange, Yellow, Grey, Blue
Light : Brown, Red, Orange, Yellow, Grey, Blue
Tones : solid colour, blemish or mottle

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: ....

WL below TOC ....

Stickup above NS: ....m

WL .... m below NS

JDA Consultant Hydrologists
Suite 1, 27 York Street
Subiaco WA 6008
Tel: 9388 2436
Fax: 9381 9279

JDA Consultant Hydrologists

LITHOLOGICAL LOG

Client: SPM Projects Marketing
Project: Lots 1 & 2 Rowley Road, Darling Downs: LWMS
Bore location: 403494 E 6439067 N
Datum: MGA94/AHD

Job No: J4264
Hole commenced: 10 Sept 2008
Hole completed: 10 Sept 2008
Logged by: SS

Bore Name: RH5
Drill type: Hand Auger
Hole diameter: 75mm

Total Depth: 1.89 m
R.L. TOC: 26.313 mAHD
Natural Surface: 26.34 mAHD

method	penetration 1 2 3	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
						COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
HA		PVC (Class 9)				Brown	Medium	Sand	Low	Dry	
					0.5m			Clayey Sand		Slightly Moist	
					1.0m	Grey	Fine	Clay		Medium	Yellow/Red Mottle
			▽	▤	1.5m	Orange	Fine to Medium			Saturated	
				▤		Grey	Fine				
					2.0m						*End of Hole*
					2.5m						
					3.0m						
					3.5m						
					4.0m						
					4.5m						
					5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: ....

WL below TOC ....

Stickup above NS: ....m

WL .... m below NS

JDA Consultant Hydrologists
Suite 1, 27 York Street
Subiaco WA 6008
Tel: 9388 2436
Fax: 9381 9279

JDA Consultant Hydrologists

LITHOLOGICAL LOG

Client: SPM Projects Marketing
Project: Lots 1 & 2 Rowley Road, Darling Downs: LWMS
Bore location: 403361 E 6439149 N
Datum: MGA94/AHD

Job No: J4264
Hole commenced: 10 Sept 2008
Hole completed: 10 Sept 2008
Logged by: SS

Bore Name: RH6
Drill type: Hand Auger
Hole diameter: 75mm

Total Depth: 2.27 m
R.L. TOC: 25.998 mAHD
Natural Surface: 25.928 mAHD

method	penetration 1 2 3	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
HA											
		PVC (Class 9)			0.5m						
					1.0m	Brown	Medium	Clay	Low	Slightly Moist	
			▽		1.5m						
				▤	2.0m						
					2.5m						
					3.0m						
					3.5m						
					4.0m						
					4.5m						
					5.0m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: ………………………………

WL below TOC ………………

Stickup above NS: …………m

WL ……………… m below NS

APPENDIX F

Groundwater Investigation Report (JDA, 2009)

Jim Davies & Associates Pty Ltd
ABN 24 067 295 569
Suite 1, 27 York Street, Subiaco
PO Box 117, Subiaco WA 6008
Ph: (08) 9388 2436
Fx: (08) 9381 9279
info@jdahydro.com.au
www.jdahydro.com.au

To : *SPM Projects Marketing*
Attention : *Anthony Mylonas*
Email : *Anthony@spmprojects.com.au*
cc :

Date : 12 Feb 2009
Our Ref : J4264e
Pages : 7

LOTS 1 AND 2 ROWLEY ROAD, DARLING DOWNS
AAMGL INVESTIGATION

Anthony,

Please find below JDA's report detailing the field investigation and analysis to calculate the predevelopment average annual maximum groundwater Level (AAMGL) for Lots 1 and 2 Rowley Road, Darling Downs (herein referred to as the Study Area).

Site Details

The study area is approximately 11.5 ha in size and is located 27 km south-east of the Perth Central Business District, in the Shire of Serpentine Jarrahdale. It is currently cleared and used for semi-rural/residential purposes.

The Study Area is classified as a palusplain multiple use wetland by the Department of Environment and Conservation in the "Geomorphic Wetlands of the Swan Coastal Plain" dataset (DEC 2006).

The Birrega Main Drain (BMD) flows beneath Rowley Road in a northerly direction and changes course midway through the Study Area flowing west under Hopskinson road and continues west to Tonkin Highway.

The Study Area is characterised by brown medium sand at the northern and eastern boundary. In the south and west of the site brown medium sand is underlain by layers of grey fine clay, beneath which there are layers of fine to medium orange clay or red sandy clay.

Field Investigation

On 9 September 2008, JDA installed 6 groundwater monitoring bores (RH1 to RH6) across the Study Area with the use of a 75 mm hand auger. The bores were augered to depths between 1.3 and 3.3 m and consisted of 50 mm PCV with end caps and 0.5m of slotted pipe.

Natural surface and top of casing levels for the bores were surveyed by Whelans Survey and Mapping to Australian Height Datum (mAHD). Table 1 provides a summary of the survey data.

Groundwater levels for the bores were measured on 22 October 2008 when groundwater levels were near their seasonal maximum. The groundwater levels are shown in Table 1.

Groundwater levels were also measured in the two Department of Water (DoW) bores T120 and T115 on the same date. The water level in the DoW bore T115 was used in the calculation of the AAMGL, however, the water level of the bore T120 was not used as it was found to be affected by localised pumping.

The location of the JDA bores and DoW bore T115 are shown in Figure 1.

Table 1. Monitoring Site Locations and Measured Groundwater Levels

Groundwater Bore	Location (GDA 94)		Natural Surface (m AHD)	Top of Casing (m AHD)	Water Level 22/10/2008	
	Easting	Northing			m bTOC	mAHD
JDA Bores: Lots 1 and 2 Rowley Road						
RH1	403161	6439183	25.81	26.55	2.12	24.43
RH2	403164	6438988	26.15	27.32	2.42	24.90
RH3	403670	6439192	26.85	27.33	1.10	26.23
RH4	403686	6438990	27.21	27.18	0.85	26.33
RH5	403495	6439067	26.34	26.31	0.92	25.39
RH6	403362	6439149	26.00	25.93	1.02	24.91
DoW Bores: Long-term Monitoring Bore						
T115	402761	6442759	24.319	24.91	2.26	22.65

DoW Historical Data

The DoW bore T115, which is located 3.6 km north of the study site along Armadale Road, has groundwater level data available for the years 1975 to 2008. This groundwater level data is shown in Figure 2.

The AAMGL of bore T115 was calculated using this historical data. The water level measured on 22 October 2008 was 22.65 mAHD which was 1.17 m below its AAMGL.

Table 2. Nearby DoW Historical Bore Data and Calculated AAMGL

Groundwater Bore	Available Historical Data	AAMGL (mAHD)	Water level on 22/10/08 (mAHD)	Difference (m)
T115	1975-2008	23.82	22.65	1.17
Difference to AAMGL (m)				**1.17**

AAMGL Calculation

Based on the historical water levels in the DoW bore, the correction to convert water levels measured in JDA bores RH1 to RH6 to AAMGL was calculated as + 1.17m (Table 2 above).

The calculated AAMGL and depth to AAMGL at each bore location is shown in Table 3.

Table 3. Calculated AAMGL and Calculated Depth to AAMGL

Bore	Natural Surface Elevation (mAHD)	Estimated AAMGL (mAHD)	Depth to AAMGL (m)
RH1	25.81	25.60	0.21
RH2	26.15	26.07	0.08
RH3	26.85	26.85	0.00
RH4	27.21	27.21	0.00
RH5	26.34	26.34	0.00
RH6	26.00	26.00	0.00

The estimated AAMGLs for bores RH3 to RH6 were all above the ground surface. These AAMGLs were corrected to natural surface elevation.

The AAMGL ranges from approximately 27.20 mAHD on the south-east side of the site and falls to 25.50 mAHD on the north-western end of the site. The groundwater flow is from east to west. AAMGL contours for the site are shown in Figure 3.

The depth to AAMGL over the study site is shown in Figure 4. These contours were generated using JDA bore AAMGLs, DOLA contours and surveyed cross-sections of BMD. The eastern half of the Study Area and a large portion of the western half of the Study Area have a depth to AAMGL of less than 0.3 m. This implies that during the winter months, the majority of study site is waterlogged.

Comparison with Regional AAMGL Mapping.

Lots 1 and 2 Rowley Road Darling Downs is bordered to the North, West and East by the Study Area of the Armadale Redevelopment Authority's Wungong Urban Water Master Plan District Water Management Strategy (Wungong DWMS, JDA et al. 2006). AAMGL contours for the Wungong DWMS are shown on Figure 3 along with the AAMGL contours for Lots 1 and 2 Rowley Road. These regional contours show the groundwater flow on the study site flowing from east to west, with the AAMGL changing from approximately 27 m AHD on the eastern edge of the study site to 25.8 m AHD on the western edge of the study site. The AAMGL for the Wungong DWMS is approximately 0.2 m less the Study Area contours on the eastern edge and approximately 0.3 m more than the Study Area AAMGL on the western edge.

In summary, the calculated contours in this investigation generally align with the Wungong DWMS contours, with localised contours differing around the BMD due the drawdown effect created by the drain.

References

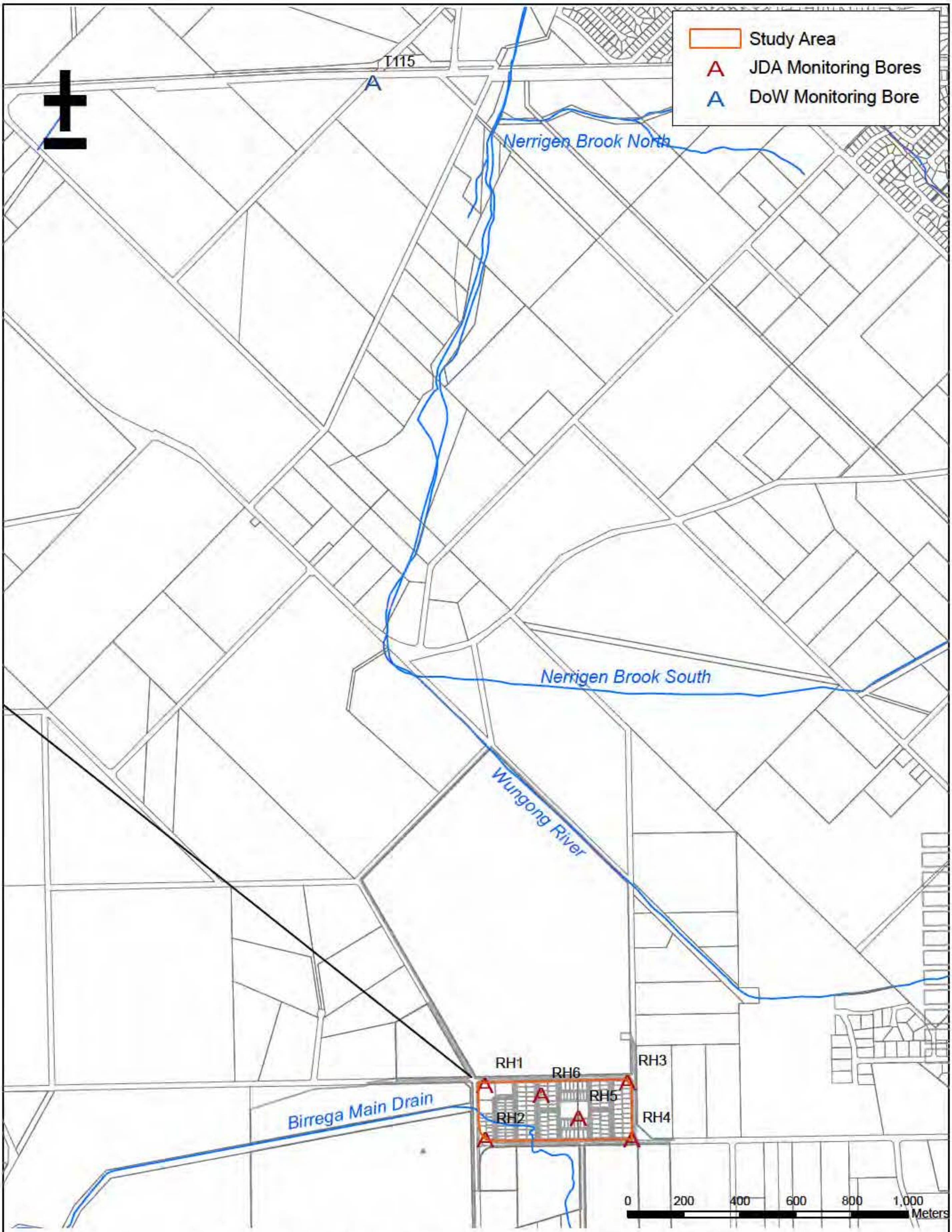
Department of Environment and Conservation (2006) Geomorphic Wetlands of the Swan Coastal Plain.

JDA Consultant Hydrologists, GHD and CSIRO (2006) Wungong Urban Water Master Plan: District Water Management Strategy, prepared on behalf of the Armadale Redevelopment Authority.

Should you have any queries regarding this report please contact Sasha Martens or Lauren Miles of this office.

Yours sincerely,

JDA CONSULTANT HYDROLOGISTS



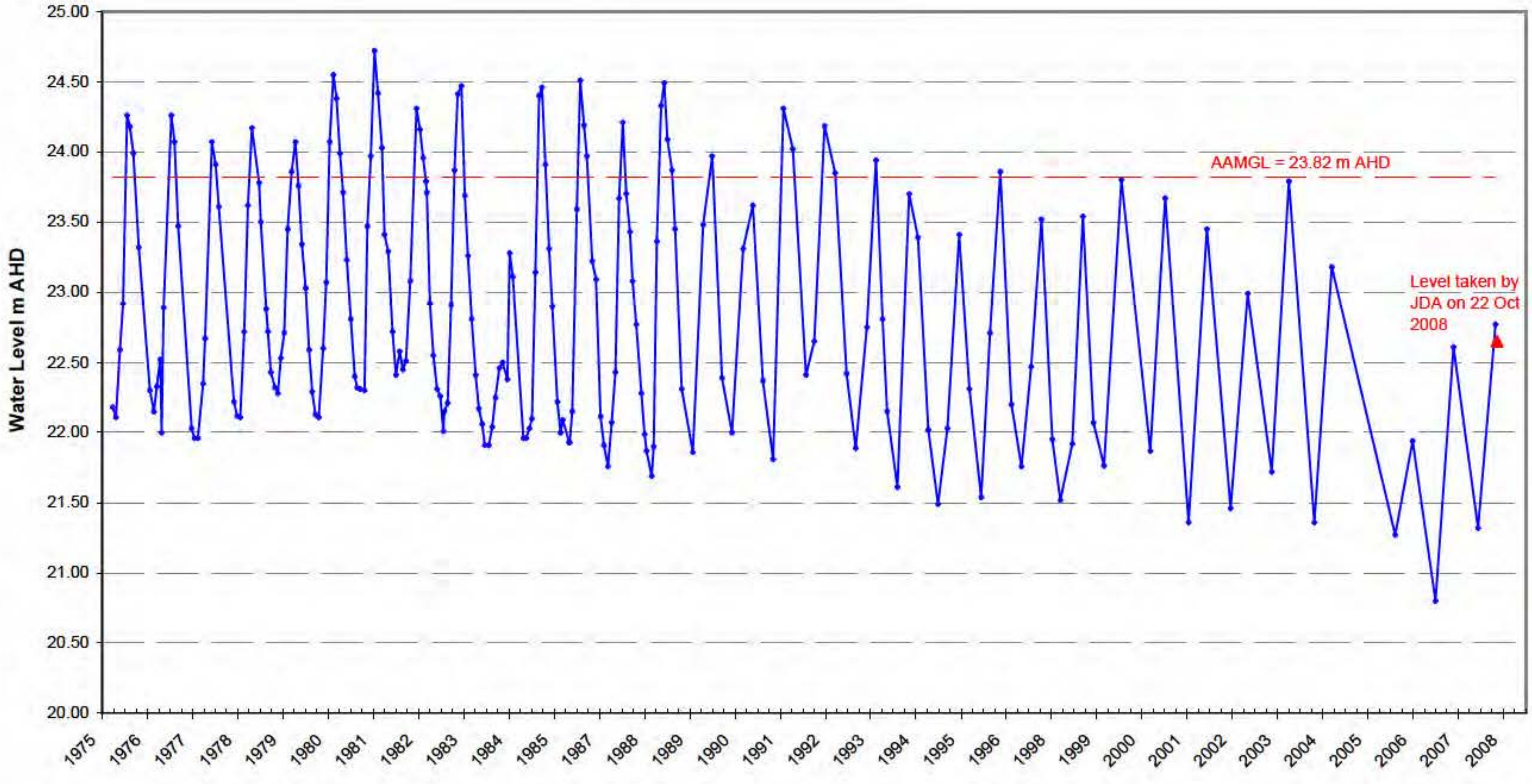
Data Source: Greg Rowe and Associates (2007) - Cadastre, Street Smart (1999) Street Directory - Birrega Main Drain and Wungong River

JDA

Job No. J4264
Scale 1:18,000

SPM Project Marketing
Lots 1 and 2 Rowley Road, Darling Downs: AAMGL Investigation

Figure 1: Monitoring Bore Locations



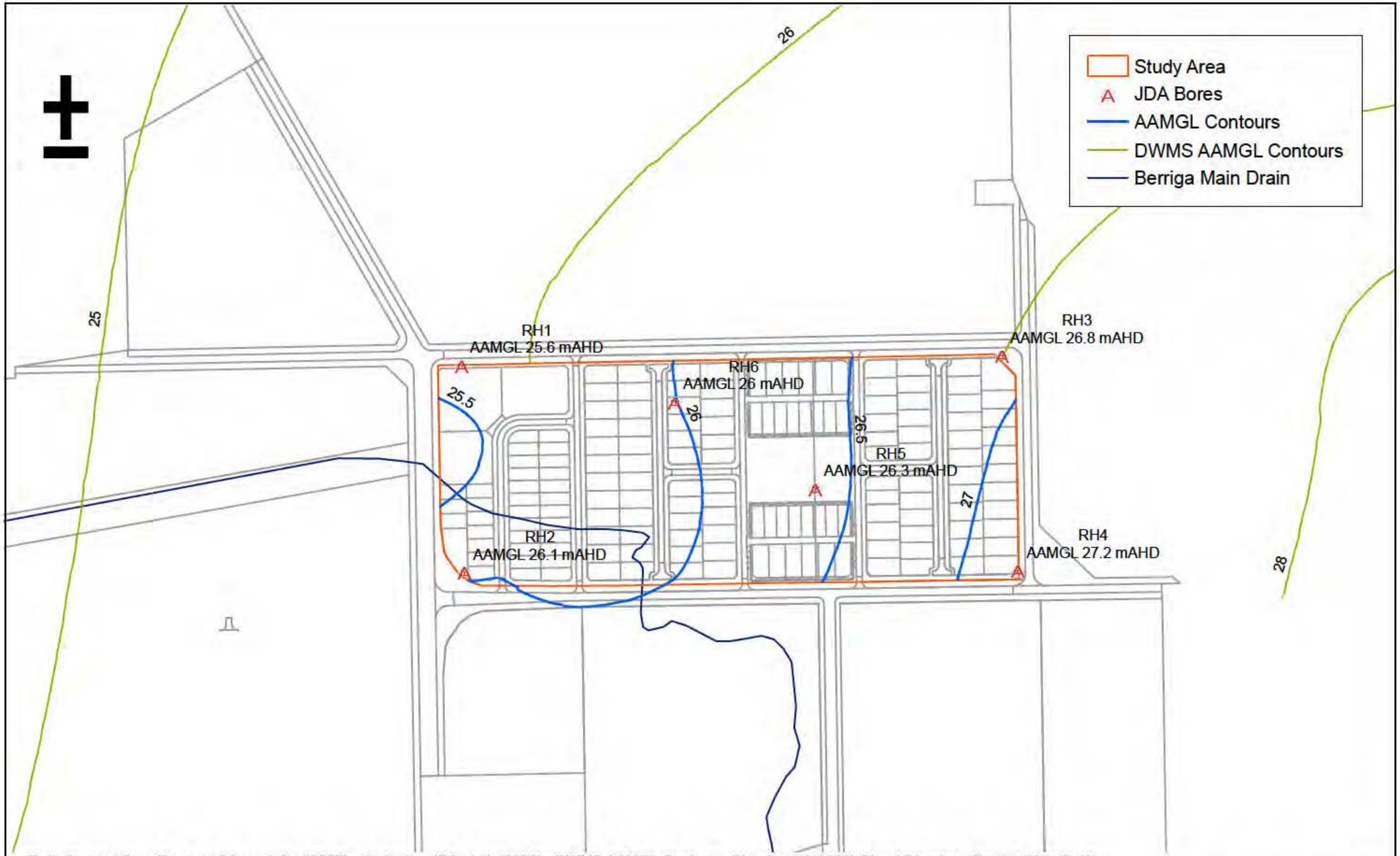
Data Source: Department of Water (2009)

Job No. J4264

SPM Project Marketing

Lots 1 and 2 Rowley Road, Darling Downs: AAMGL Investigation

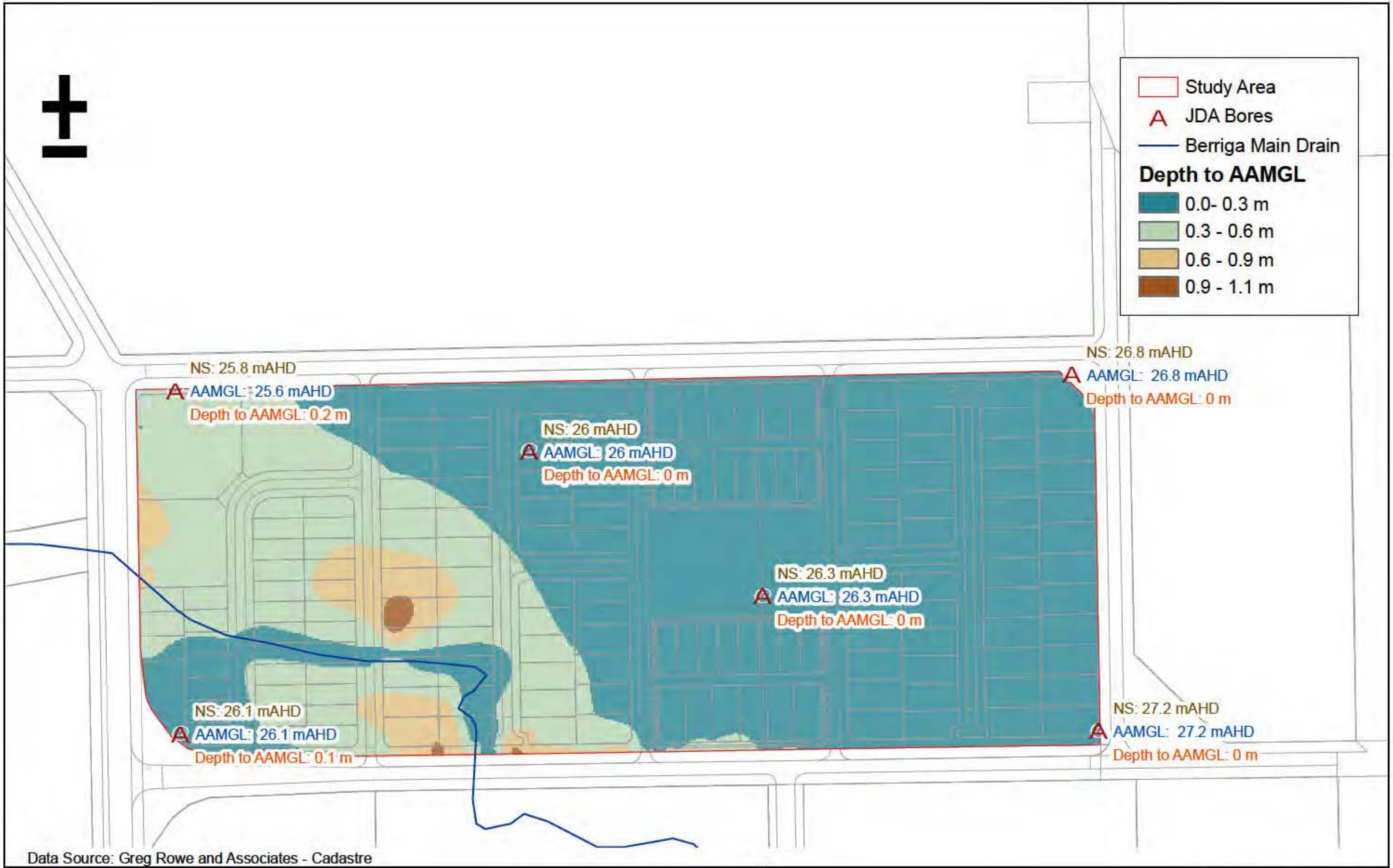
Figure 2: DoW Bore T115 Hydrograph



Data Source: Greg Rowe and Associates (2007) - Cadastre, JDA et al. (2006) - DWMS AAMGL Contours, Streetsmart (1999) Street Directory -Berriga Main Drain

Job No. J4264
Scale: 1:5,000
0 50 100 150 200 Meters

SPM Project Marketing
Lots 1 and 2 Rowley Road, Darling Downs: AAMGL Investigation
Figure 3: AAMGL Contours



Data Source: Greg Rowe and Associates - Cadastre

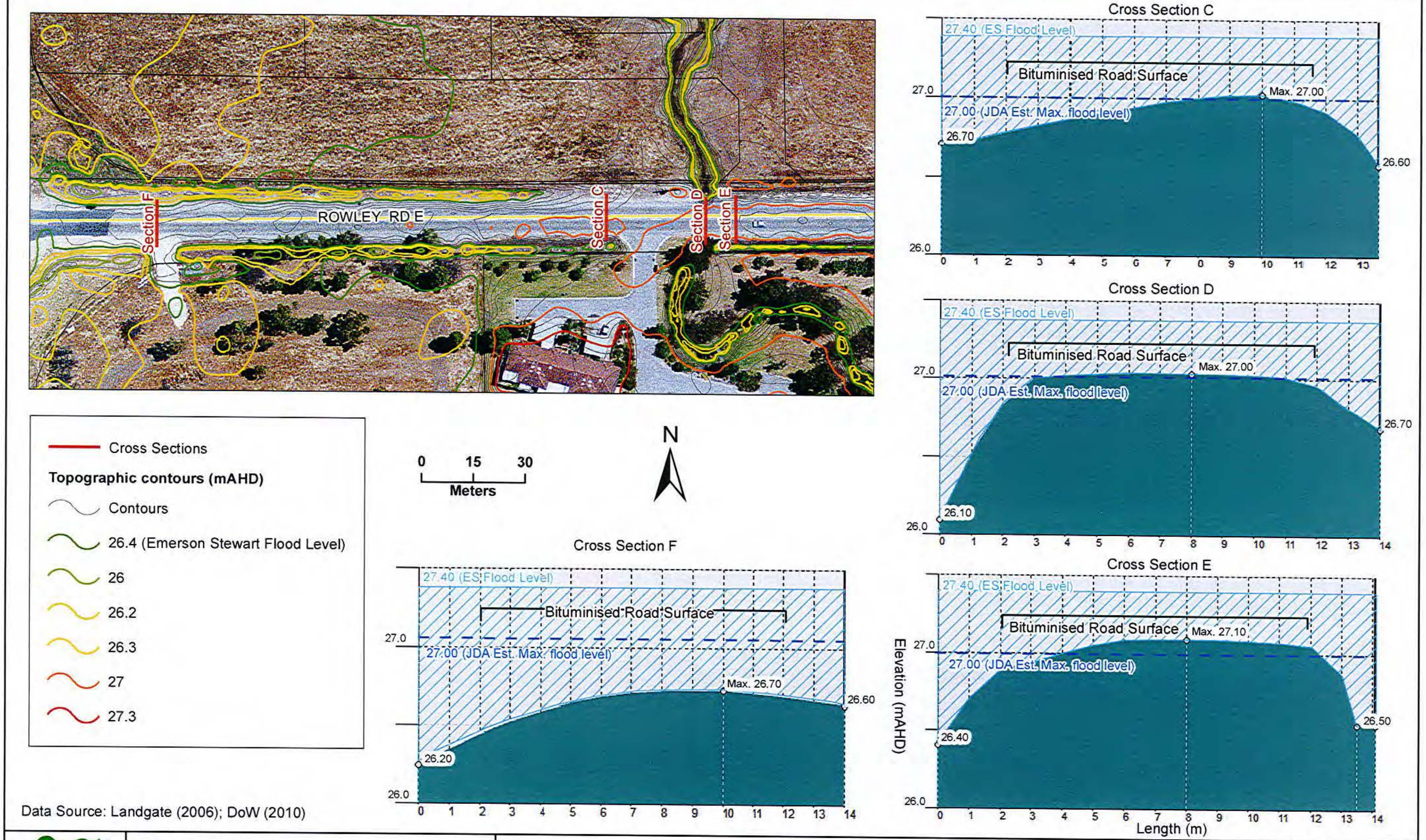
JDA

Job No. J4264
Scale: 1:3,000

SPM Project Marketing
Lots 1 and 2 Rowley Road, Darling Downs: AAMGL Investigation
Figure 4: Depth to AAMGL

APPENDIX G

Floodplain Mapping Analysis



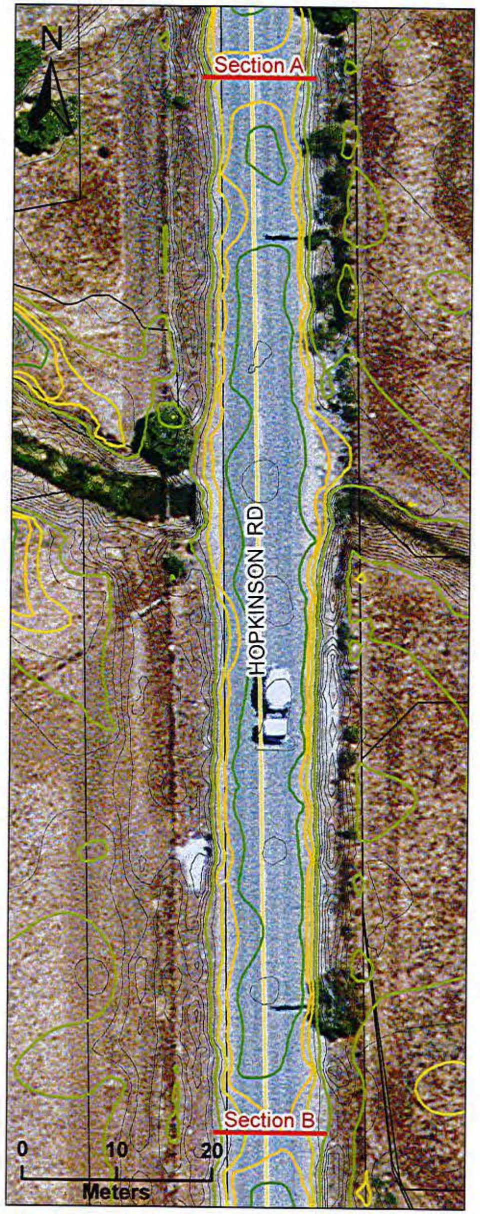
Data Source: Landgate (2006); DoW (2010)

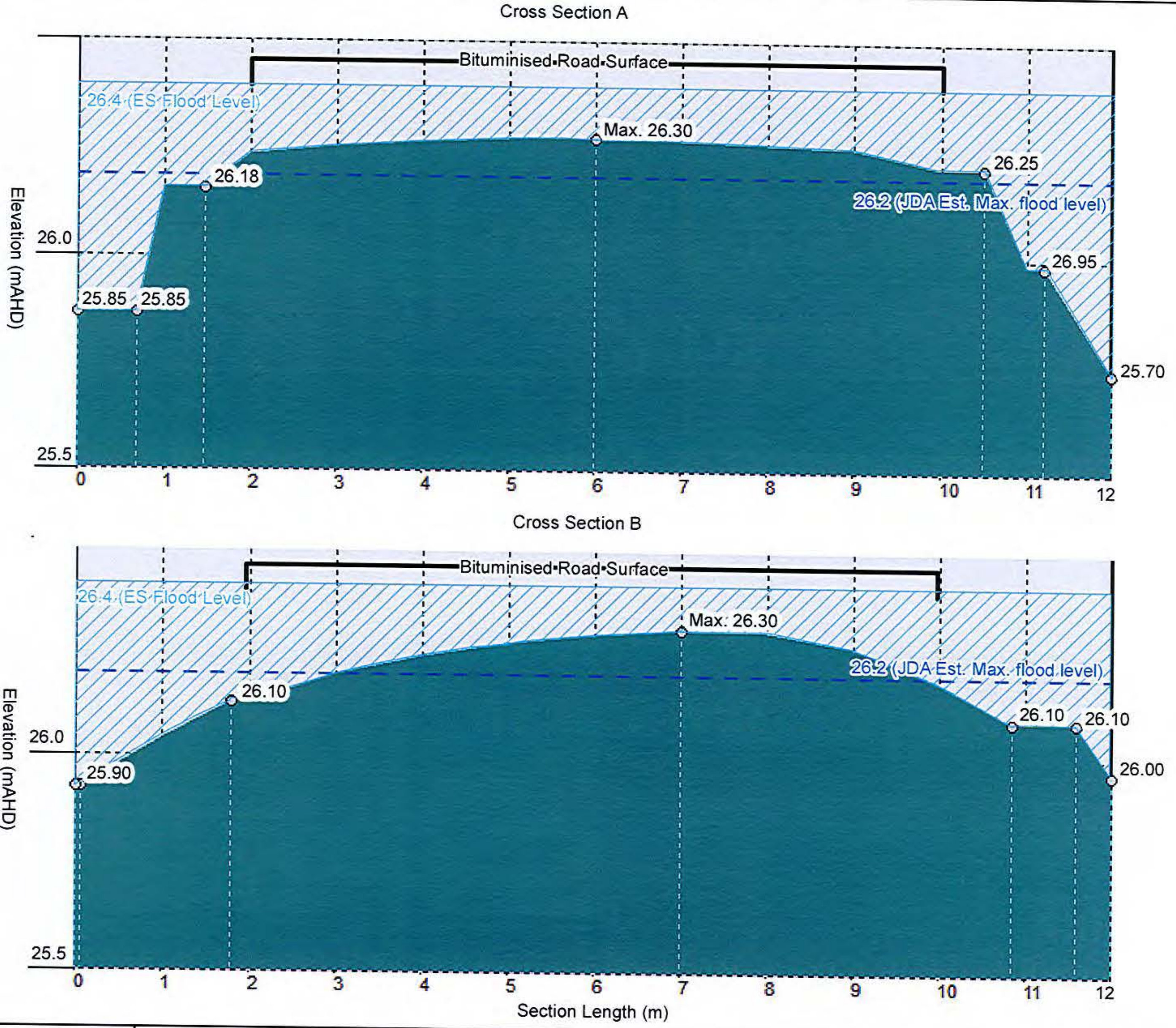
JDA Consultant Hydrologists

Job No. J4264
Scale 1:1,500

SPM Project Marketing
Lots 1 & 2, Rowley Rd, Darling Downs: LWMS

Figure G1: Rowley Rd Cross Sections





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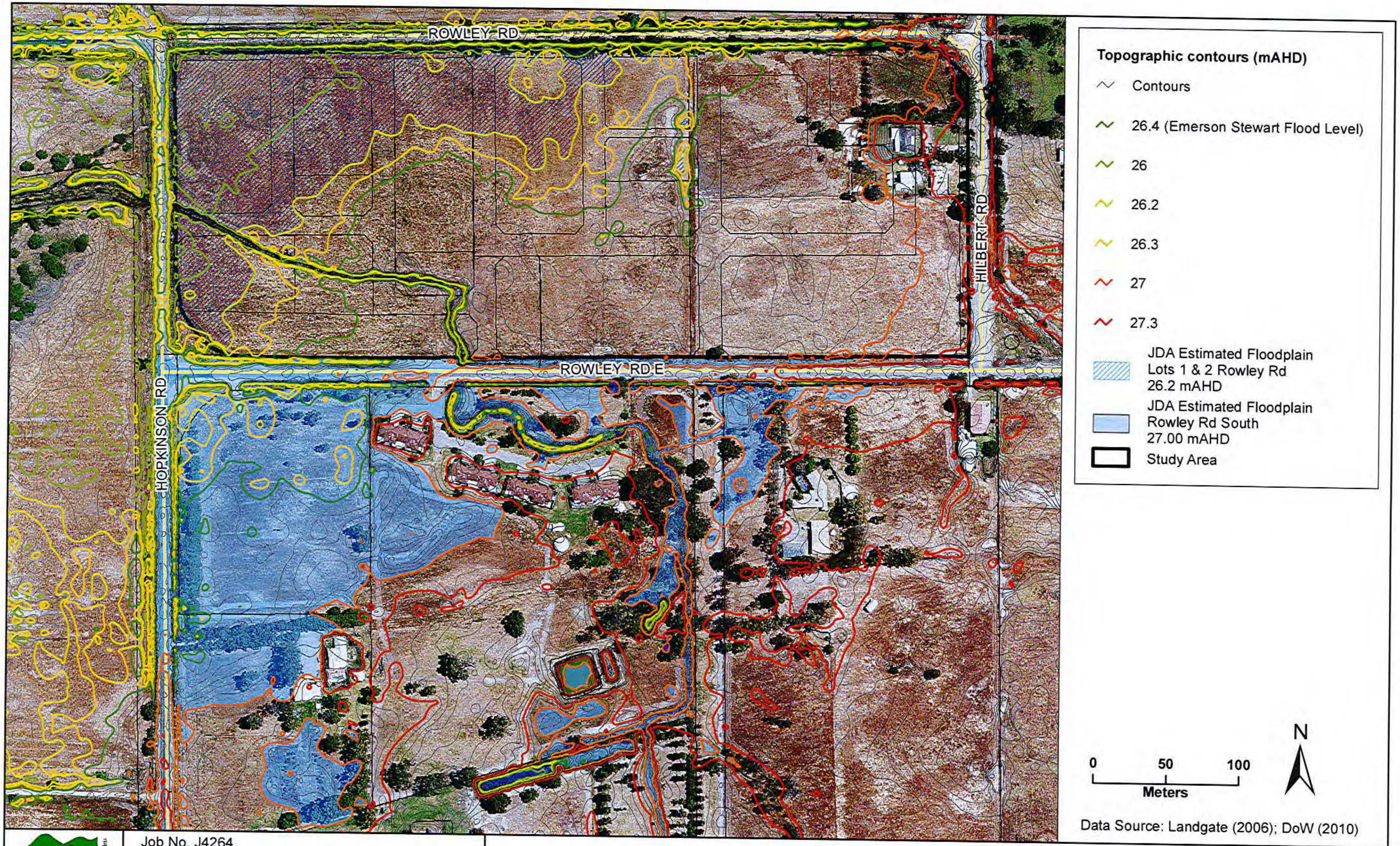
Job No. J4264
Scale 1:800

SPM Project Marketing
Lots 1 & 2, Rowley Rd, Darling Downs: LWMS
Figure G2: Hopkinson Rd Cross Sections



Data Source: Landgate (2006); DoW (2010)

Job No. J4264
Scale 1:3,500

SPM Project Marketing
Lots 1 & 2, Rowley Rd, Darling Downs: LWMS

Figure G3: Flood Level Analysis Contours

APPENDIX H

Nutrient Input Modelling Results

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005

JDA Consultant Hydrologists
Report Date : 22-Jun-09

Lot 1 and 2 Rowley Rd	
Total Nutrient Input - No WSUD (kg/yr)	248
Reduction due to WSUD (kg/yr)	0
Percentage Overall Reduction	0.0%
Pecentage Development Reduction	0.0%
Cost of Selected Program ($/kg/yr)	$0

● Total Phosphorus
○ Total Nitrogen

Catchment Name	Lot 1 and 2 Rowley Rd	
Option Description	Pre-Development Scenario	
Catchment Area	12.4	ha

Land Use Breakdown

Residential : ~R15	0.0%	lower density residential areas (excludes road reserve area)
Residential : ~R35	0.0%	higher density residential areas (excludes road reserve area)
Road Reserves : Minor	0.0%	maintainance of verge by landowners
Road Reserves : Major	0.0%	maintainance of verge by local authority
POS : Active	0.0%	grassed areas
POS : Passive / Basins	0.0%	native vegetation
Rural : Pasture	100.0%	general pasture
Rural : Residential ~R2.5/R5	0.0%	low density
Rural : Poultry	0.0%	specific high nutient input land use
Commercial/Industrial	0.0%	town centre etc

Total Residential	0.0%
Total Area	100.0%

Nutrient Input Without WSUD

Residential	Garden	0.00	kg/net ha/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Lawn	0.00		0.00		0		0.0%
	Pet Waste	0.00		0.00		0		0.0%
	Car Wash	0.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
POS	Garden/Lawn	2.60	kg/ha POS/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Pet Waste	0.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
Road Reserve	Major Roads	1.04	kg/ha RR/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Minor Roads	20.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
Rural	Pasture	20.00	kg/ha Rural/yr	20.00	kg/gross ha/yr	248	kg/yr	100.0%
	Poultry Farms	75.00		0.00		0		0.0%
	Residential (R2.5/R5)	4.00		0.00		0		0.0%
	Sub Total			20.00		248		100.0%
			Total	**20.00**	kg/gross ha/yr	**248**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☐ Native Gardens (Lots - Garden) ☐ Native Gardens (Lots - Lawn) ☐ Native Gardens (POS) ☐ Street Sweeping
☐ Community Education : Fertiliser ☐ Community Education : Pet Waste ☐ Community Education : Car Wash

Education Effectiveness 0%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (POS)	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Fertiliser	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Pet Waste	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Car Wash	0%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	0%	0.00	0	0.0%	$0	$0	$0.0
Totals		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☐ Gross Pollutant Trap ☐ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	0%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	0%	0.00	0	0.0%	$0	$0	$0.0
Total		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Nutrient Input : Residential Area without WSUD	0.00	0	0.0%			
Nutrient Input : Rural Area	20.00	248	100.0%			
Removal via Source Control	0.00	0	0.0%	$0	$0	$0.0
Removal via In-Transit Control	0.00	0	0.0%	$0	$0	$0.0
Total Removal	0.00	0	0.0%	$0	$0	$0.0
Net Nutrient Input	**20.00**	**248**	**100.0%**			

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005
JDA Consultant Hydrologists
Report Date : 22-Jun-09

Lot 1 and 2 Rowley Rd	
Total Nutrient Input - No WSUD (kg/yr)	744
Reduction due to WSUD (kg/yr)	0
Percentage Overall Reduction	0.0%
Pecentage Development Reduction	0.0%
Cost of Selected Program ($/kg/yr)	$0

○ Total Phosphorus
● Total Nitrogen

Catchment Name	Lot 1 and 2 Rowley Rd	
Option Description	Pre-Development Scenario	
Catchment Area	12.4	ha

Land Use Breakdown

Residential : ~R15	0.0%	lower density residential areas (excludes road reserve area)
Residential : ~R35	0.0%	higher density residential areas (excludes road reserve area)
Road Reserves : Minor	0.0%	maintainance of verge by landowners
Road Reserves : Major	0.0%	maintainance of verge by local authority
POS : Active	0.0%	grassed areas
POS : Passive / Basins	0.0%	native vegetation
Rural : Pasture	100.0%	general pasture
Rural : Residential ~R2.5/R5	0.0%	low density
Rural : Poultry	0.0%	specific high nutient input land use
Commercial/Industrial	0.0%	town centre etc

Total Residential	0.0%
Total Area	100.0%

Nutrient Input Without WSUD

Residential	Garden	0.00	kg/net ha/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Lawn	0.00		0.00		0		0.0%
	Pet Waste	0.00		0.00		0		0.0%
	Car Wash	0.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
POS	Garden/Lawn	73.40	kg/ha POS/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Pet Waste	0.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
Road Reserve	Major Roads	29.36	kg/ha RR/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Minor Roads	132.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
Rural	Pasture	60.00	kg/ha Rural/yr	60.00	kg/gross ha/yr	744	kg/yr	100.0%
	Poultry Farms	175.00		0.00		0		0.0%
	Residential (R2.5/R5)	15.20		0.00		0		0.0%
	Sub Total			60.00		744		100.0%
			Total	60.00	kg/gross ha/yr	744	kg/yr	100.0%

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☐ Native Gardens (Lots - Garden) ☐ Native Gardens (Lots - Lawn) ☐ Native Gardens (POS) ☐ Street Sweeping
☐ Community Education : Fertiliser ☐ Community Education : Pet Waste ☐ Community Education : Car Wash

Education Effectiveness 0%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (POS)	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Fertiliser	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Pet Waste	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Car Wash	0%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	0%	0.00	0	0.0%	$0	$0	$0.0
Totals		0.00	0	0.0%	$0	$0	$0.0

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☐ Gross Pollutant Trap ☐ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	0%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	0%	0.00	0	0.0%	$0	$0	$0.0
Total		0.00	0	0.0%	$0	$0	$0.0

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Nutrient Input : Residential Area without WSUD	0.00	0	0.0%			
Nutrient Input : Rural Area	60.00	744	100.0%			
Removal via Source Control	0.00	0	0.0%	$0	$0	$0.0
Removal via In-Transit Control	0.00	0	0.0%	$0	$0	$0.0
Total Removal	0.00	0	0.0%	$0	$0	$0.0
Net Nutrient Input	60.00	744	100.0%			

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005

JDA Consultant Hydrologists
Report Date : 22-Jun-09

Lot 1 and 2 Rowley Rd	
Total Nutrient Input - No WSUD (kg/yr)	151
Reduction due to WSUD (kg/yr)	46
Percentage Overall Reduction	30.6%
Pecentage Development Reduction	30.6%
Cost of Selected Program ($/kg/yr)	$81

● Total Phosphorus
○ Total Nitrogen

Catchment Name	Lot 1 and 2 Rowley Rd	
Option Description	Post-Development Scenario : With WSUD	
Catchment Area	12.4	ha

Land Use Breakdown

Residential : ~R15	0.0%	lower density residential areas (excludes road reserve area)		
Residential : ~R35	60.0%	higher density residential areas (excludes road reserve area)		
Road Reserves : Minor	20.0%	maintainance of verge by landowners		
Road Reserves : Major	0.0%	maintainance of verge by local authority		
POS : Active	20.0%	grassed areas		
POS : Passive / Basins	0.0%	native vegetation		
Rural : Pasture	0.0%	general pasture		
Rural : Residential ~R2.5/R5	0.0%	low density	Total Residential	60.0%
Rural : Poultry	0.0%	specific high nutient input land use	Total Area	100.0%
Commercial/Industrial	0.0%	town centre etc		

Nutrient Input Without WSUD

Residential	Garden	8.10	kg/net ha/yr	4.86	kg/gross ha/yr	60	kg/yr	39.8%
	Lawn	3.50		2.10		26		17.2%
	Pet Waste	0.00		0.00		0		0.0%
	Car Wash	0.13		0.08		1		0.7%
	Sub Total			7.04		87		57.7%
POS	Garden/Lawn	2.60	kg/ha POS/yr	0.52	kg/gross ha/yr	6	kg/yr	4.3%
	Pet Waste	3.23		0.65		8		5.3%
	Sub Total			1.17		14		9.5%
Road Reserve	Major Roads	1.04	kg/ha RR/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Minor Roads	20.00		4.00		50		32.8%
	Sub Total			4.00		50		32.8%
Rural	Pasture	20.00	kg/ha Rural/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Poultry Farms	75.00		0.00		0		0.0%
	Residential (R2.5/R5)	4.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
			Total	12.21	kg/gross ha/yr	151	kg/yr	100.0%

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☑ Native Gardens (Lots - Garden) ☑ Native Gardens (Lots - Lawn) ☑ Native Gardens (POS) ☑ Street Sweeping
☑ Community Education : Fertiliser ☑ Community Education : Pet Waste ☑ Community Education : Car Wash

Education Effectiveness 20%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	30%	1.46	18	11.9%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (POS)	30%	0.16	2	1.3%	$0	$0	$0.0
Community Education : Fertiliser	100%	1.58	20	13.0%	$0	$130	$6.6
Community Education : Pet Waste	100%	0.13	2	1.1%	$0	$171	$107.0
Community Education : Car Wash	100%	0.02	0	0.1%	$0	$130	$655.6
Street Sweeping	100%	0.25	3	2.1%	$0	$1,023	$323.9
Totals		3.59	45	29.5%	$0	$1,455	$32.6

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☑ Gross Pollutant Trap ☐ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	100%	0.14	2	1.2%	$23,312	$893	$1,309.7
Water Pollution Control Ponds	0%	0.00	0	0.0%	$0	$0	$0.0
Total		0.14	2	1.2%	$23,312	$893	$1,309.7

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Nutrient Input : Residential Area without WSUD	12.21	151	100.0%			
Nutrient Input : Rural Area	0.00	0	0.0%			
Removal via Source Control	3.59	45	29.5%	$0	$1,455	$32.6
Removal via In-Transit Control	0.14	2	1.2%	$23,312	$893	$1,309.7
Total Removal	3.74	46	30.6%	$23,312	$2,347	$80.9
Net Nutrient Input	8.47	105	69.4%			

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005
JDA Consultant Hydrologists
Report Date : 22-Jun-09

Lot 1 and 2 Rowley Rd	
Total Nutrient Input - No WSUD (kg/yr)	845
Reduction due to WSUD (kg/yr)	204
Percentage Overall Reduction	24.2%
Pecentage Development Reduction	24.2%
Cost of Selected Program ($/kg/yr)	$18

○ Total Phosphorus
● Total Nitrogen

Catchment Name	Lot 1 and 2 Rowley Rd
Option Description	Post-Development Scenario : With WSUD
Catchment Area	12.4 ha

Land Use Breakdown

Residential : ~R15	0.0%	lower density residential areas (excludes road reserve area)
Residential : ~R35	60.0%	higher density residential areas (excludes road reserve area)
Road Reserves : Minor	20.0%	maintainance of verge by landowners
Road Reserves : Major	0.0%	maintainance of verge by local authority
POS : Active	20.0%	grassed areas
POS : Passive / Basins	0.0%	native vegetation
Rural : Pasture	0.0%	general pasture
Rural : Residential ~R2.5/R5	0.0%	low density
Rural : Poultry	0.0%	specific high nutient input land use
Commercial/Industrial	0.0%	town centre etc

Total Residential	60.0%
Total Area	100.0%

Nutrient Input Without WSUD

Residential	Garden	17.70	kg/net ha/yr	10.62	kg/gross ha/yr	132	kg/yr	15.6%
	Lawn	23.10		13.86		172		20.3%
	Pet Waste	0.00		0.00		0		0.0%
	Car Wash	0.04		0.02		0		0.0%
	Sub Total			24.50		304		35.9%
POS	Garden/Lawn	73.40	kg/ha POS/yr	14.68	kg/gross ha/yr	182	kg/yr	21.5%
	Pet Waste	12.90		2.58		32		3.8%
	Sub Total			17.26		214		25.3%
Road Reserve	Major Roads	29.36	kg/ha RR/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Minor Roads	132.00		26.40		327		38.7%
	Sub Total			26.40		327		38.7%
Rural	Pasture	60.00	kg/ha Rural/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Poultry Farms	175.00		0.00		0		0.0%
	Residential (R2.5/R5)	15.20		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
			Total	68.16	kg/gross ha/yr	845	kg/yr	100.0%

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☑ Native Gardens (Lots - Garden)
☑ Native Gardens (Lots - Lawn)
☑ Native Gardens (POS)
☑ Street Sweeping
☑ Community Education : Fertiliser
☑ Community Education : Pet Waste
☑ Community Education : Car Wash

Education Effectiveness 20%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	30%	3.19	40	4.7%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (POS)	30%	4.40	55	6.5%	$0	$0	$0.0
Community Education : Fertiliser	100%	7.09	88	10.4%	$0	$130	$1.5
Community Education : Pet Waste	100%	0.52	6	0.8%	$0	$171	$26.8
Community Education : Car Wash	100%	0.00	0	0.0%	$0	$130	$2,403.8
Street Sweeping	100%	0.58	7	0.9%	$0	$1,023	$141.6
Totals		15.78	196	23.2%	$0	$1,455	$7.4

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☑ Gross Pollutant Trap
☐ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	100%	0.68	8	1.0%	$23,312	$893	$271.6
Water Pollution Control Ponds	0%	0.00	0	0.0%	$0	$0	$0.0
Total		0.68	8	1.0%	$23,312	$893	$271.6

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Nutrient Input : Residential Area without WSUD	68.16	845	100.0%			
Nutrient Input : Rural Area	0.00	0	0.0%			
Removal via Source Control	15.78	196	23.2%	$0	$1,455	$7.4
Removal via In-Transit Control	0.68	8	1.0%	$23,312	$893	$271.6
Total Removal	16.46	204	24.2%	$23,312	$2,347	$18.3
Net Nutrient Input	51.70	641	75.8%			

NiDSS Core Data & Cost Calculations

Nutrient Input Decision Support System
Version 2.0 March 2005

JDA

Analysis Type (1,2)	2	TN	0%	% of total residential area as ~R15
Ave lots/net ha		0.0	0%	% of total residential Area as ~R35

Discount Rate 6%

Community Education Information

"Who Cares About the Environment ?" (NSW EPA, 2000) Survey
17% stated environment one of two most important issues for govt to address
Of these 27% stated water as most important environmental issue
17% stated education most important issue to protect environment
Impact assumed to reduce fertiliser applications to minimum rates

Fertiliser Application Information/Assumptions

Lots assumed fertilised by property owner
Minor Road Reserves fertilised by property owner (verge assumed 40% road reserve)
Major Road Reserves fertilised by local authority (verge assumed 40% road reserve)
Active POS fertilised by local authority
Passive POS not fertilised
Rural Land Use and Poultry Farms have no reductions due to WSUD applied

Pet Waste

Data Source

Pets per lot and disposal via JDA Survey (2001)
TP & TN application via Gerritse at al (1991)
Cost Estimate via JDA. Distribution cost and frequency is for brochure, bag cost is for POS's

Application Rates

	TN (kg/yr)	TP (kg/yr)	TN or TP specified	Survey Results Pets Per Lot R15	R35	R zoning specified
Cats	0.90	0.20	0.90	0.24	0.16	0.00
Sml Dogs	2.75	0.70	2.75	0.12	0.16	0.00
Med Dogs	5.50	1.40	5.50	0.16	0.08	0.00
Lge Dogs	8.25	2.10	8.25	0.19	0.00	0.00

Waste Disposal

	R15	R35	R zoning specified
Lot	35%	0%	0%
POS	6%	12%	0%
Bins	59%	88%	0%

Cost Data

Distribution	$1.00	per house
Frequency	2	years
Bag Costs	$2.50	per 100 bags

Cost Calculation

Total Residential Area	-	ha
Total Number of Lots	-	
Area to Apply	-	ha
Number of Lots to Apply	-	
Number of Dogs	-	
Disposing in POS	-	
POS bags per year	-	
Cost of bags per year	$0	
Cost of mailout per year	$0	
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

Car Wash

Data Source

Frequency based on JDA Survey (2001)
TN/TP based on Polyglaze Autowash data via CRC for Freshwater Ecology (Canberra)
Cost Estimate via JDA. Distribution cost and frequency is for brochure

Application Rates & Washing Frequency

Car wash detergent TN kg/wash	TP kg/wash	TN or TP specified	Washing Frequency (one car every x weeks) R15	R35	R zoning specified
0.00009	0.00033	0.00009	2	4.5	0.00

Cost Data

Distribution	$1.00	per house
Frequency	2	years

Cost Calculation

Number of Lots	-	
Cost of mailout	$0	per year
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

Lot Fertiliser

Data Source

Mean Fertiliser Applications via JDA survey (2001)
% garden and lawns estimated via Aerial photography JDA(2001) for various suburbs with similar zonings
Minimum Fertiliser Applications via product recommended application data

Application Rates

	Fertiliser mean application kg TN/sqm/yr	kg TP/sqm/yr	TN or TP specified
Garden	0.059	0.027	0.05900
Lawn	0.033	0.005	0.03300

	Fertiliser min application kg TN/sqm/yr	kg TP/sqm/yr	TN or TP specified
Garden	0.010	0.003	0.01000
Lawn	0.009	0.001	0.00900

	Education Campaign Fertiliser Reduction kg TN/sqm/yr	kg TP/sqm/yr	TN or TP specified	% redn
Garden	0.049	0.024	0.04900	83%
Lawn	0.024	0.004	0.02400	73%

Garden and Lawn Areas

	R15	R35	R zoning specified
% garden	0.11	0.03	0.00
% lawn	0.28	0.07	0.00

Cost Data

Distribution	$1.00	per house
Frequency	2	years

Cost Calculation

Number of Lots	-	
Cost of mailout	$0	per year
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

POS Fertiliser

Data Source

Application rates based on City of Armadale application to active POS areas in years 1996-2000

Application Rates

	Fertiliser mean application kg TN/ha POS/yr	kg TP/ha POS/yr	TN or TP specified
POS	73.4	2.6	73.40

NiDSS Core Data & Cost Calculations

Nutrient Input Decision Support System
Version 2.0 March 2005

JDA

Rural Land Use Fertiliser

Data Source

Estimates via Gerritse et al (1992) for pasture

Application Rates

	Fertiliser mean application		TN or TP
	kg TN/ha Rural/yr	kg TP/ha Rural/yr	specified
Rural	60	20	60.00

Poultry Farms

Data Source

Estimates via Gerritse (et al) 1992
Based on 14000 hens on 42 ha property

Application Rates

	Fertiliser mean application		TN or TP
	kg TN/ha farm/yr	kg TP/ha farm/yr	specified
Poultry	175	75	175.00

Street Sweeping

Data Source

Street Sweeping Revisited - Nutrients and Metals in Particle Size Fractions of Road Sediment
from two major roads in Perth (Davies & Pierce 1999), Water 99 Joint Congress Brisbane
Cost based on Davies & Pierce (1998), $55/km

Estimated Removal Rate
(assumes no WSUD upstream)

	Potential Reduction (kg/gross ha/yr)		TN or TP	reduction due to upstream
	TN	TP	specified	WSUD
Sweeping	0.75	0.35	0.75	0%

Cost Data

Cost	$55.00	$/km
Frequency	6	times per year

Cost Calculation

Cost	$0	$/gross ha/yr
Area to Apply	0.0	ha
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

Note : Street sweeping applied to developed areas only - not existing rural land use areas not to be developed

In-Transit Controls - Stormwater Nutrient Load

Data Source

Nutrients in Perth Urban Surface Drainage Catchments Characterised by Applicable Attributes, Tan (1991)

Data Used to Calculate Nutrients in Stormwater Available for Removal by In-Transit Controls
Removal quantities are for no WSUD and are reduced in calcs based on upstream measures used

Estimated Stormwater Nutrient Load
(assumes no WSUD upstream)

Typical Phosphorus Stormwater Load (Perth Urban Areas)	0.40	kg/gross ha/yr
Typical Nitrogen Stormwater Load (Perth Urban Areas)	2.53	kg/gross ha/yr

TN or TP specified
2.53

Gross Pollutant Trap

Data Source

Approximate average retention value via JDA(2001) - GeoTrap Laboratory Test Report
Based on GeoTrap, Humesceptor, Downstream Defender, CDS
Cost of GPT's via CRC report 98/3 (Allison, Chiew and McMahon) April 1998

Estimated Removal Rate

	Percentage Removal		TN or TP
	TN	TP	specified
GPT	35%	50%	35%

Cost Data

Capital Cost	$1,880	per ha
Maintenance	$72	per ha/year

Cost Calculation

Area to Apply	0.0	ha
Total PV Cost	$0	
Removal	0.0	kg/year
Cost per kg	$0	

Note : GPT's applied to developed areas only - not existing rural land use areas not to be developed

Water Pollution Control Pond

Data Source

TP removal efficiency and cost via Henley Brook Drive WPCP Conceptual Design (JDA,1997)
TN efficiency via Managing Urban Stormwater Treatment Techniques (NSW EPA 1997)

Estimated Removal Rate

	Percentage Removal		TN or TP
	TN	TP	specified
WPCP	35%	50%	35%

Cost Data

Capital Cost	$1,800,000	
Maintenance	$25,000	per year
Removal	34	kg TP/year

Cost Calculation

Cost per kg	$884	per kg
Removal	0.0	kg/year
Capital Cost	$0	
Operating	$0	
Total PV Cost	$0	

Note : WPCP's applied to developed areas only - not existing rural land use areas not to be developed

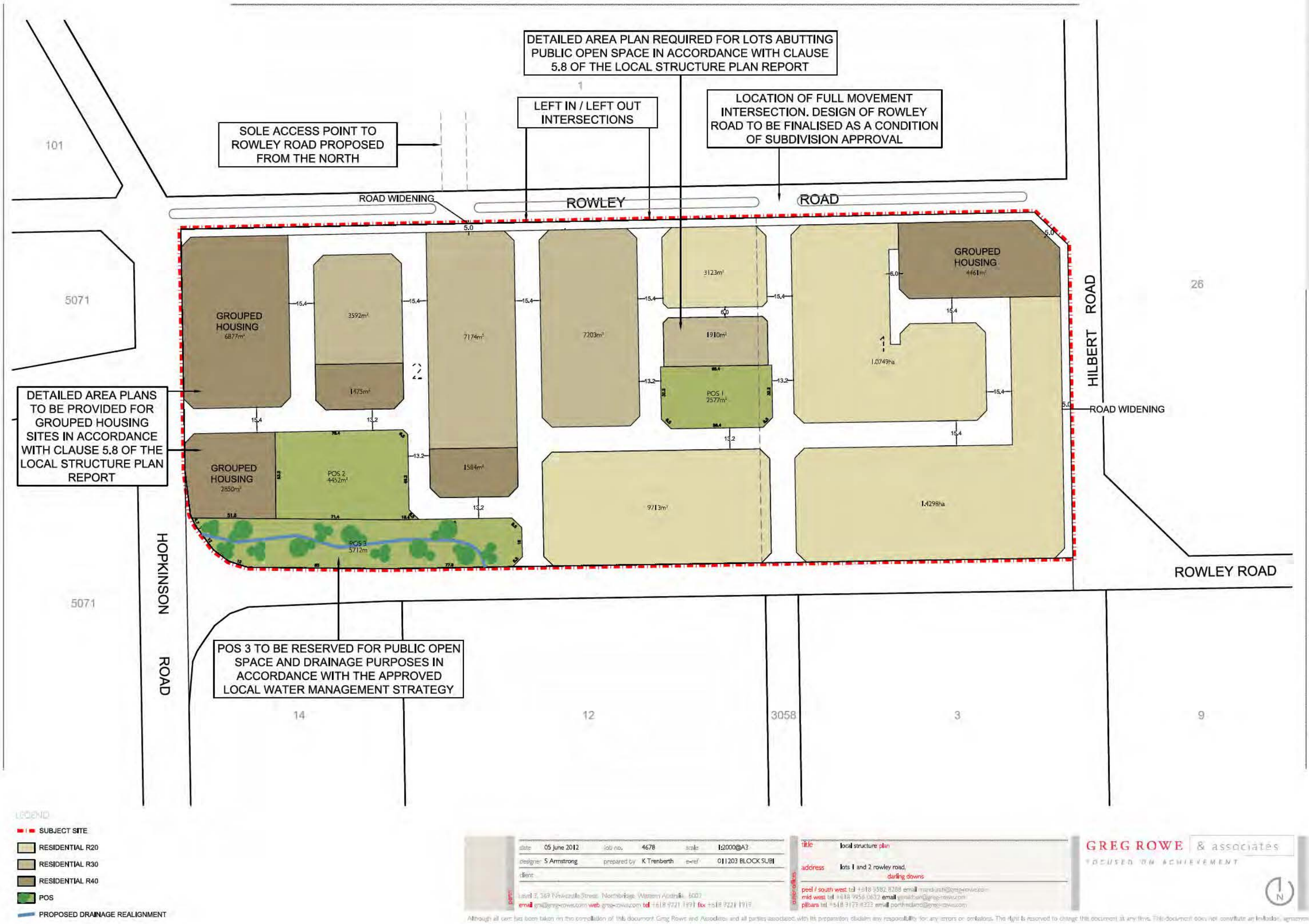
Suite 1, 27 York St, Subiaco WA 6008
PO Box 117, Subiaco WA 6904
Ph: +61 8 9388 2436
Fx: +61 8 9381 9279

www.jdahydro.com.au

info@jdahydro.com.au

APPENDIX 6

PROPOSED LOCAL STRUCTURE PLAN



date 05 June 2012
job no. 4678
scale 1:2000@A3
designer S Armstrong
prepared by K Trenberth
e-ref 01|203 BLOCK SUBI
client

perth
Level 3, 369 Newcastle Street, Northbridge, Western Australia 6003
email gra@greg-rowe.com web greg-rowe.com tel +618 9221 1991 fax +618 9221 1919

title local structure plan
address lots 1 and 2 rowley road, darling downs

other offices
peel / south west tel +618 9582 8288 email mandurah@greg-rowe.com
mid west tel +618 9956 0632 email geraldton@greg-rowe.com
pilbara tel +618 9173 4333 email porthedland@greg-rowe.com

GREG ROWE & associates
FOCUSED ON ACHIEVEMENT

SJS TRIM - IN12/8716

GREG ROWE | & associates
FOCUSED ON ACHIEVEMENT

7/6/12

att Wendy Joy ref 4678

re: Lots 1 and 2 Rowley Road, Darling Downs.

- electronic copy attached as requested.

SHIRE OF
14 JUN 2012
SERPENTINE JARRAHDALE

Regards
Simon Armstrong

www.greg-rowe.com
perth office Level 3, 369 Newcastle Street, Northbridge, Western Australia 6003 **tel** +618 9221 1991 **fax** +618 9221 1919 **email** gra@greg-rowe.com

SJS TRIM - IN12/8716

APPENDIX 2

PRE-CONSULTATION LODGEMENT

TABLE 5. PRE-LODGEMENT CONSULTATION

AGENCY	DATE OF CONSULTATION	METHOD OF CONSULTATION	SUMMARY OF OUTCOME
Shire of Serpentine Jarrahdale	July – August 2015	Email/ Telephone	Preparation of new SP required incorporating modifications under WAPC Structure Plans guidelines format (i.e. Part I & II sections). Proposed modifications to approved structure plan supported in-principle.
Department of Planning	July 2015	Email/telephone discussion	WAPC *Planning Bulletin 112/ 2015 Medium-Density Single House Development Standards – Structure Plan Areas* may be incorporated into the existing approved local structure plan as an amendment to the structure plan.
Water Corporation	*Circa* 03/2015	Email/telephone discussion	Project engineer and officers at Water Corporation resolved that south-west public open space area to be increased to accommodate local and district drainage.

APPENDIX 3

LOCAL WATER MANAGEMENT STRATEGY ADDENDUM

hyd2o
HYDROLOGY

12 August 2016

Your Ref:
Our Ref: H15064Av2

Department of Water
107 Breakwater Pde
Mandurah Ocean Marina
Mandurah, WA 6210

ATTENTION: Brett Dunn

Dear Brett,

RE: LOTS 1 & 2 ROWLEY RD, LOCAL WATER MANAGEMENT STRATEGY ADDENDUM

This addendum has been prepared by Hyd2o on behalf of Terranovis to update design information previously provided in the *Lot 1 & 2 Rowley Rd, Local Water Management Strategy* (JDA, 2010).

Since the LWMS was prepared and approved the Department of Water (DoW) has published the *Birrega and Oaklands flood modelling and drainage study: Supporting the Birrega and Oaklands Drainage and Water Management Plan* (DoW, 2015) that includes modelling of the Birrega drain within the site.

This addendum seeks to use the predevelopment data provided by the DoW from this study to inform the post-development design of the site and assist with the development of subsequent Urban Water Management Plans.

1. Site Background

The site is 12 ha in size and located on Rowley Rd, Darling Downs in the Shire of Serpentine- Jarrahdale. The following summarises the physical characteristics of the site:

- Topography of the site is generally flat between 26 mAHD and 27 mAHD with soils being a mix of sandy clay soils.
- JDA (2010) reported that the average annual maximum groundwater table is generally within 0.3m-1m of existing ground surface.
- The Birrega Main Drain (BMD) traverses the south western portion of the site entering through a culvert under Rowley Rd and exiting under Hopkinson Rd. There are a number of other smaller culverts under Hopkinson Rd that convey flood flows from the site downstream.

2. DoW Pre Development Regional Scale Modelling

As part of the *Birrega and Oaklands flood modelling and drainage study: Supporting the Birrega and Oaklands*, DoW established a regional 2D flood model of the area including Birrega Main Drain. This model was established based on a 30m cellular grid. Some local refinement of this model was then undertaken by DoW in February 2015 which included the stamping in of actual road elevations at the site and also including in the model the main culverts under Hopkinson Rd and Rowley Rd.

Key DoW modelling results for the site for the critical 24 hour 100 year average recurrence interval (ARI) event are shown in Figure 1 and Table 1. According to DoW's modelling, Hopkinson Rd (RL 26.30 mAHD) is overtopped during the 100 year ARI event. Peak flows through the main culverts are estimated as 1.28 m^3/s (900 mm dia) and 0.70 m^3/s (550 mm x 1200 mm box), with 1.13 m^3/s overtopping the road. The DoW estimated a total peak outflow from the site of 3.12 m^3/s. A total peak outflow hydrograph is provided in Figure 2.

A peak water level of 26.35 mAHD at Hopkinson Rd is reached which equates to a total flood storage provided by the site of 11,100 m^3.

The time of concentration from the site is 6.65 hrs.

All peak flow modelling inputs were provided to Calibre on 18 September, 2015 by the DoW (Paola Duarte, pers comm). The DoW provided the following advice regarding management of flood events:

"The regional storage can be used to manage the local water that comes off the development ONLY if it is shown that the time of concentration of the catchment and the time of concentration of the local development do not meet and cause an increase in flood height at the outlet of the development. When this happens, additional storage will need to be provided" (Paola Duarte, pers comm).

Table 1: Summary of DoW Regional Modelling Results for Lots 1&2 Rowley Rd

Parameter	DoW Regional Model Result
Hopkinson Rd Culvert Peak Outflow (m^3/s) (900 mm diameter)	1.28
Hopkinson Rd Culvert Peak Outflow (m^3/s) (550mm x 1200mm box culvert)	0.70
Hopkinson Rd Road Overtopping (m^3/s)	1.13
Flood Level at Hopkinson Rd (mAHD)	26.35
Modelled Flood Storage on Site (m^3)	11,100

3. Calibre Post Development Flood Modelling

A local scale flood model was compiled by Calibre Consulting in XP-Storm to integrate the regional scale flood modelling (by DoW) with the local scale flood modelling being undertaken to facilitate the current subdivision. The proposed development is shown in Figure 3.

This modelling was undertaken to determine if the proposed local flood storage areas and the regional flood storage area could be combined due to the different times of concentration of the catchment without impacting on the total peak outflow from the site at Hopkinson Rd.

The model was calibrated to the DoW pre development results by Hyd2o in 2014 with Calibre making revisions of the calibrated model to reflect the proposed post development design (Figure 3). The post-development case included a total storage volume of 11,285 m^3 within the site with following breakdown of storage areas from Calibre (2015);

- The Birrega Drain storage basin with a volume capacity of 7,630 m^3
- Lot soakwells total volume 490 m^3
- Road Reserve Storage: 110 m^3
- Pit & Pipe Volume: 100 m^3
- Local flood storage within POS: 2955 m^3

The following key assumptions were included in the model:

- Updated regional inflow hydrographs were provided by DoW (September 2015) for the critical duration 24hr storm event.
- A post development local inflow hydrograph was generated from the proposed subdivision design including local subdivision flood storage (Calibre, 2015). Total flood storage of 3,655 m^3 was estimated as a part of the proposed development (Calibre, 2015).
- A tailwater condition downstream of Hopkinson Rd of approximately 25.98 mAHD was adopted. This level was based on previous DoW model output data and used as an effective calibration parameter in the model.

4. Calibre Modelling Results

The Calibre model estimated the total post development outflow to be 3.03 m^3/s and the DoW modelled total post development outflow was estimated as 3.12 m^3/s. A comparison of peak flow hydrographs is shown in Figure 2.

Calibre estimated the time of concentration for the subdivision to be 36.1 minutes and the DoW estimated the time of concentration as 6.65 hrs for the Birrega Main Drain (Calibre, 2015). The subdivision in turn has a much shorter time of concentration and can access the regional storage prior to it being required to manage the regional flood event.

Calibre post-development modelling of the site was undertaken using the DRAINS model and was presented to the DoW in the *Lot 1 Hilbert Rd and Lot 2 Hopkinson Rd, Darling Downs Urban Water Management Plan* (TME, 2014). The outflow hydrograph from the subdivision estimated a peak flow of 0.20 m^3/s considerably lower than the predevelopment modelling undertaken by the DoW estimated a peak flow of 0.35 m^3/s. A comparison of hydrographs is shown in Figure 4. Calibre have therefore effectively provided an 'over compensation of flow" post development from the site within the local storages.

5. Guidelines for Future Urban Water Management Plans

The modelling results indicate that a post-development storage volume of 11,285 m^3 to provide both regional flood storage and local flood storage within the site, will not impact on the post development outflow (Calibre, 2015) of the site.

Subsequent Urban Water Management Plans should provide adequate local storage design detail to ensure that a total storage of 11,285 m^3 can be achieved.

With respect to monitoring requirements for the development, these are addressed in detail in the JDA (2010) LWMS and TME (2014) UWMP. Monitoring requirement for futures stages will be appropriately detailed in subsequent UWMP's.

6. References

Calibre (2015), Lots 1 & 2 Rowley Rd Birrega Main Drains Investigation Storage Volume Capacity Requirements

Department of Water (2015) Birrega and Oaklands flood modelling and drainage study: Supporting the Birrega and Oaklands Drainage and Water Management Plan (DoW, 2015)

JDA(2010), Lot 1 & 2 Rowley Rd, Local Water Management Strategy.

TME (2014), Lot 2 Hopkinson Rd, Darling Downs Urban Water Management Plan.

Should you have any queries regarding this report, please do not hesitate to contact Sasha Martens or Suzanne Smart of this office.

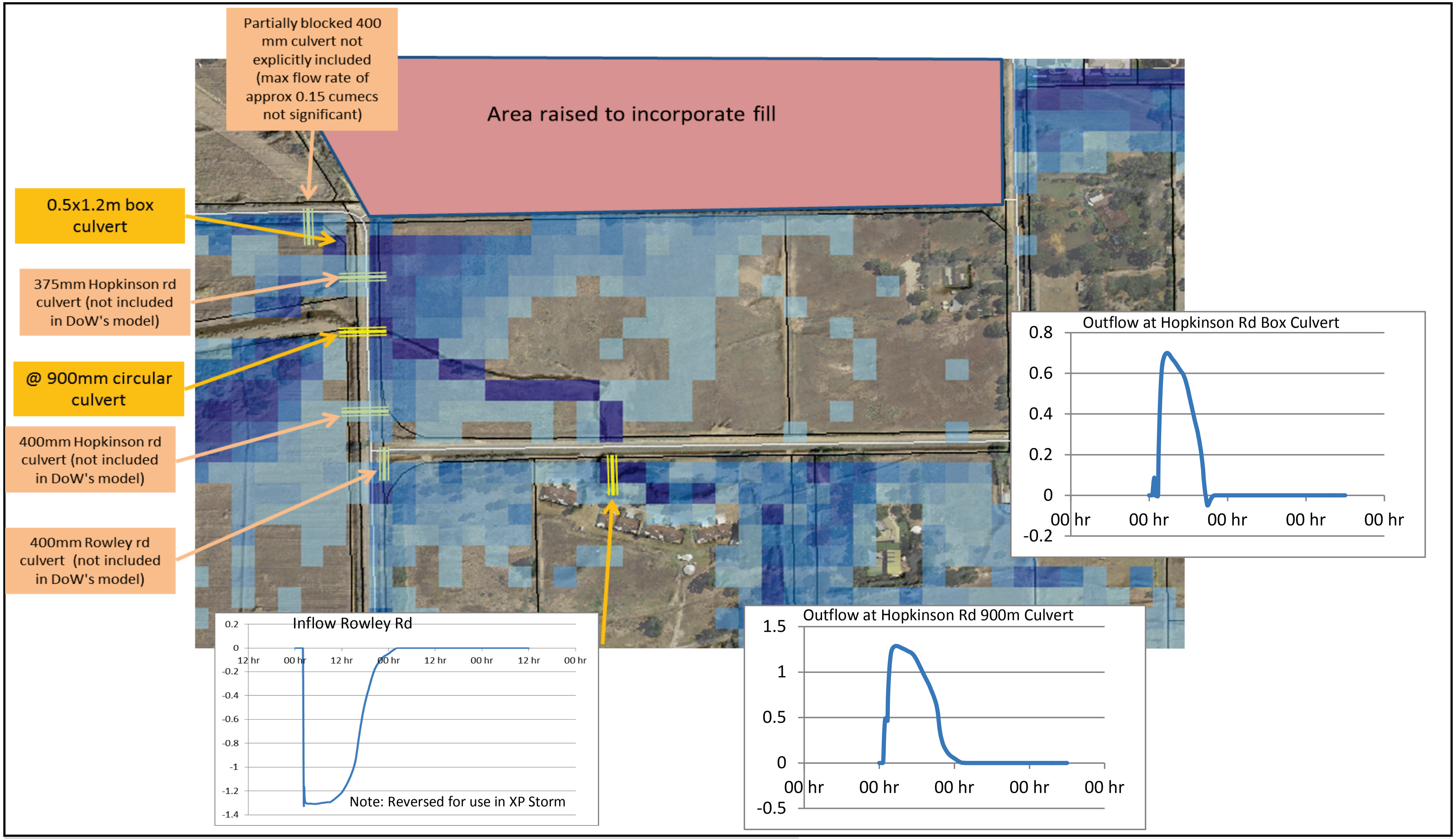
Yours sincerely,

Suzanne Smart

Suzanne Smart

Senior Environmental Hydrologist

Date :12/10/2015 Job No H15064



Partially blocked 400 mm culvert not explicitly included (max flow rate of approx 0.15 cumecs not significant)

Area raised to incorporate fill

0.5x1.2m box culvert

375mm Hopkinson rd culvert (not included in DoW's model)

@ 900mm circular culvert

400mm Hopkinson rd culvert (not included in DoW's model)

400mm Rowley rd culvert (not included in DoW's model)

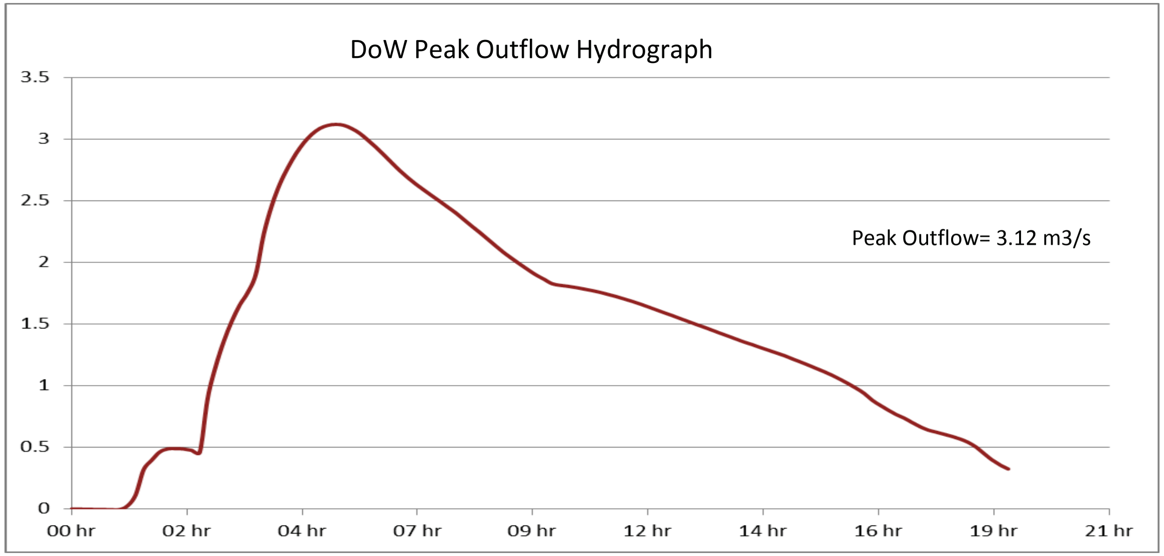
Note: Reversed for use in XP Storm

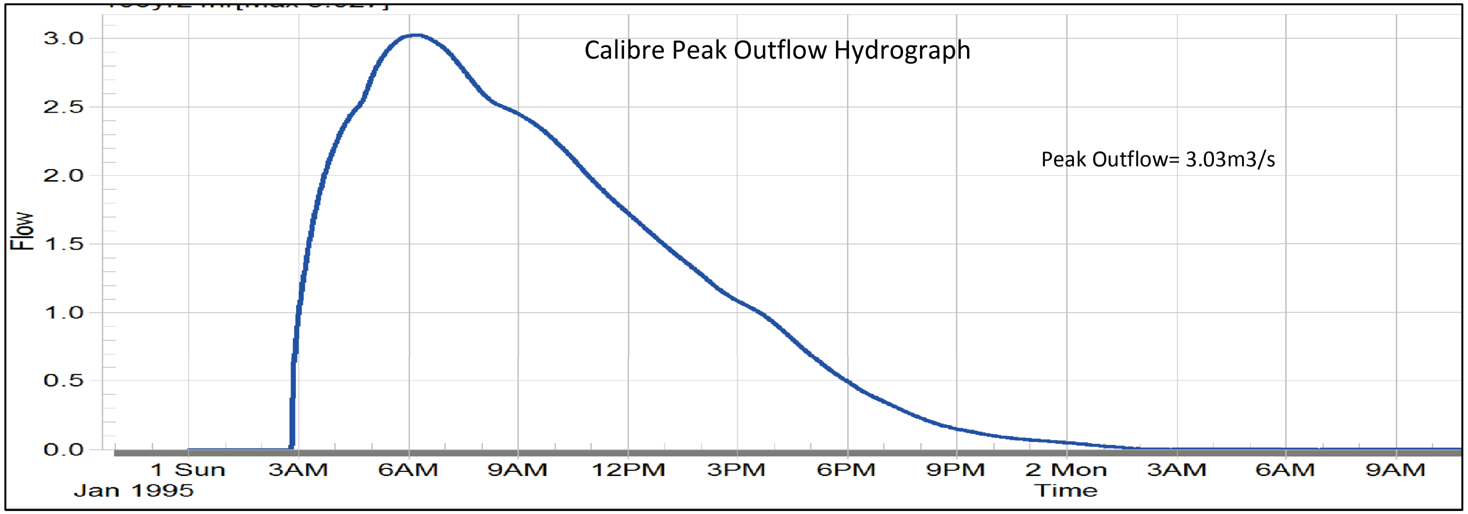
hyd$_2$o

Lots 1&2 Rowley Rd LWMS Addendum

Department of Water Regional Model Outputs

Figure 1





Source: DoW 2015 and Calibre 2015

hyd$_2$o

Lot 1 & 2 Rowley Rd LWMS Addendum

Total Flow Hydrographs

Figure 2

Date :12/8/2016 Job No H15064

Local Storage Volume Summary

Lot Soakwells: 490 m3

Road Reserve Storage: 110 m3

Pit & Pipe Volume: 100m3

Storage and Catchment A and Catchment B drainage: 2955 m3

Source : Whelans Precalculation Plan Drawining No 16086-000-002-07, 20/8/2015

Volumes via Calibre (2015)

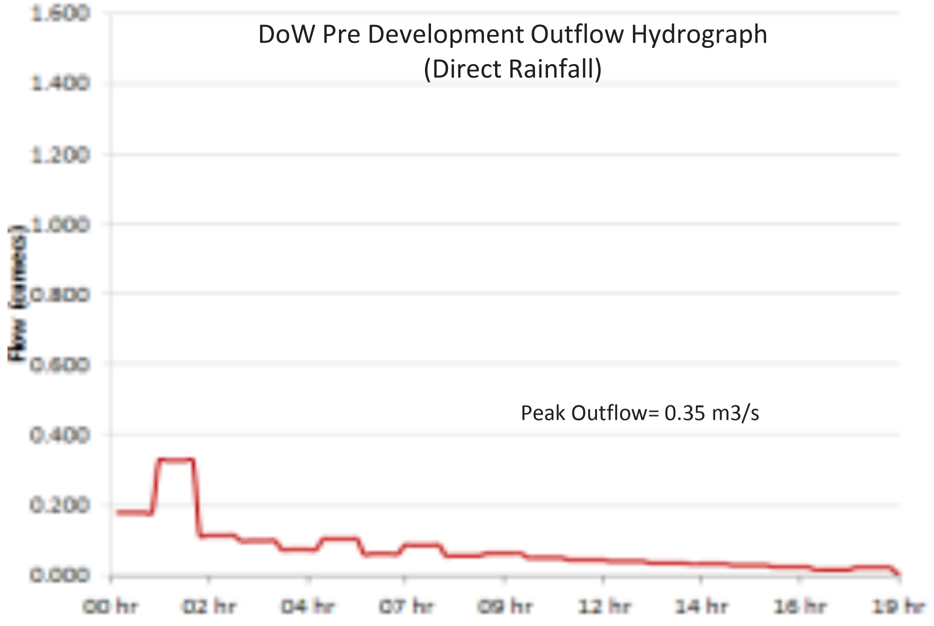
hyd₂o

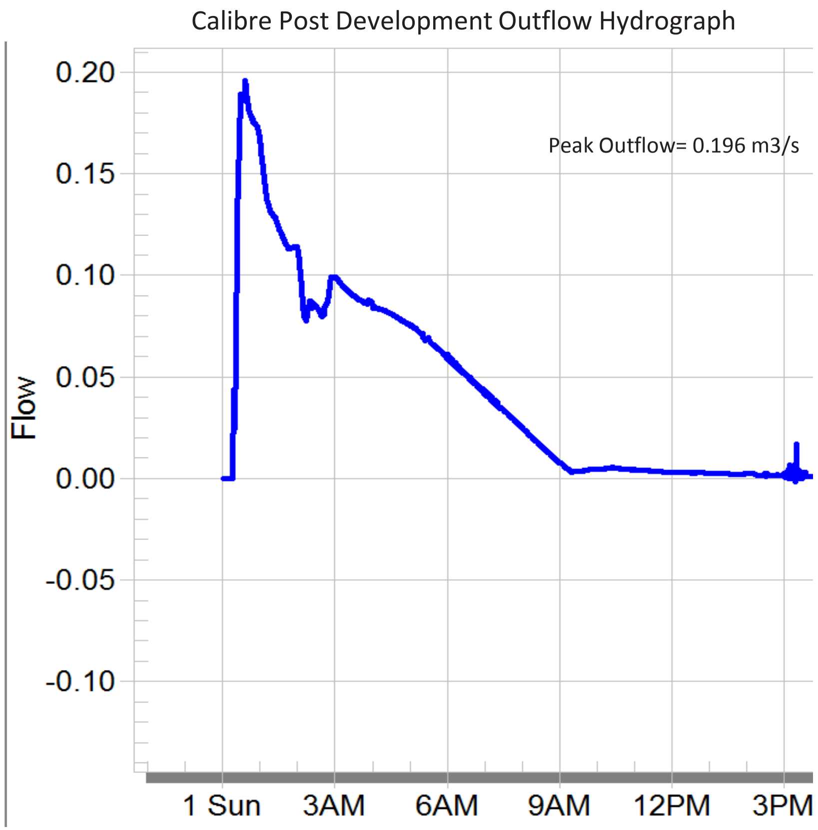
Lots 1&2 Rowley Rd LWMS Addendum

Proposed Subdivision

Figure 3

Date :13/10/15 Job No H15064





Source: DoW 2015 and Calibre 2015

hyd$_2$o

Lot 1 & 2 Rowley Rd LWMS Addendum

Site Hydrographs (Pre and Post Development)

Figure 4

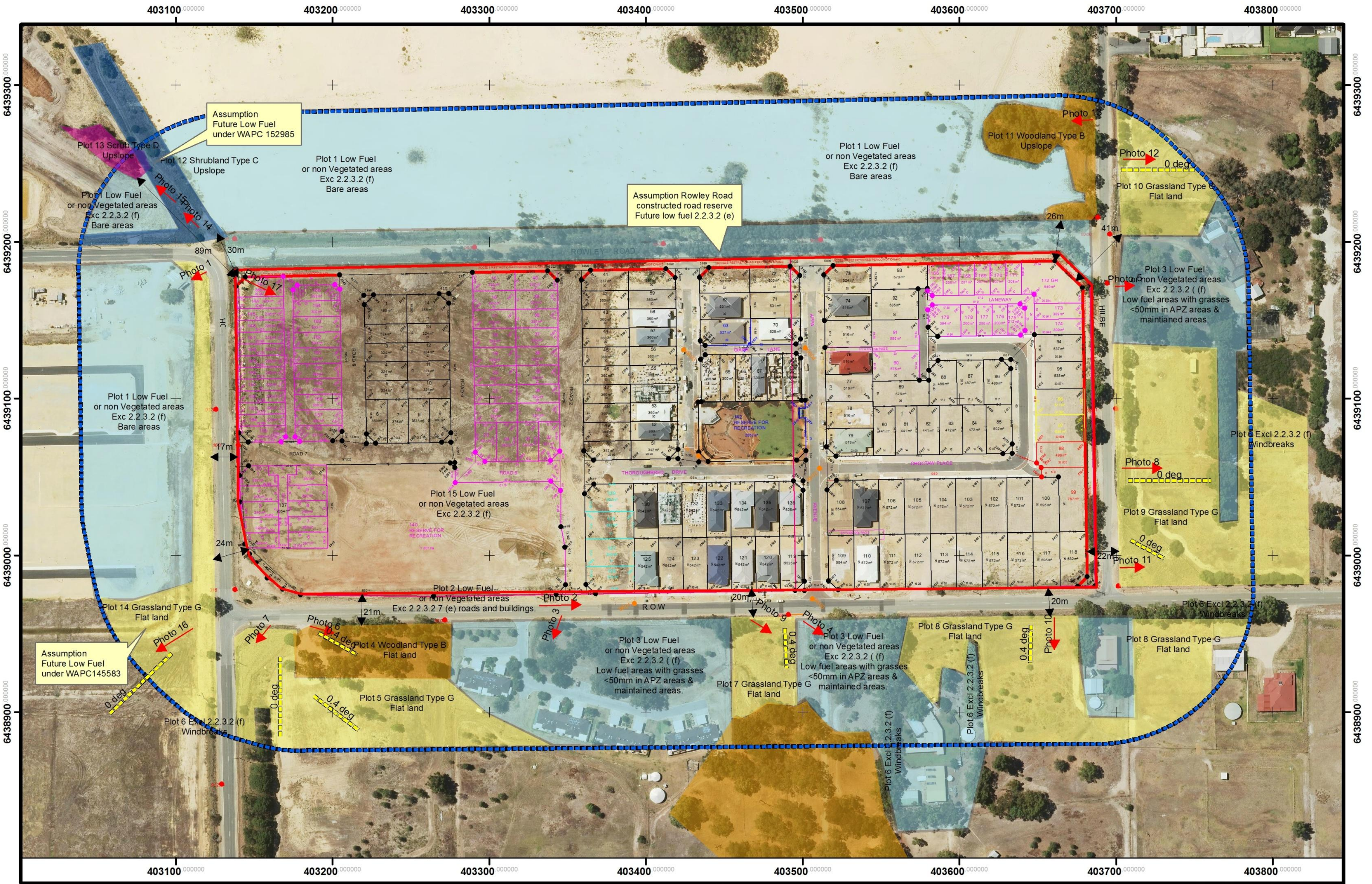
APPENDIX 4

BAL CONTOUR PLAN & ASSESSMENT

AS 3959 Bushfire Attack Level (BAL) Contour Plan Report

Site Details			
Project Name	Rowley Road Development BAL Contour Plan		
Address:	(Lots 1 & 2 on Dia 50969) Rowley Road		
Suburb:	Darling Downs	**State:**	WA
Local Government Area:	Shire of Serpentine-Jarrahdale		
Description of Building Works:	Subdivision Development		
Stage of WAPC Planning	WAPC subdivision application (s)		

Report Details			
Report / Job Number:	TER011	**Report Version:**	FINAL
Assessment Date:	8/4/16	**Report Date:**	8/8/2016



Legend

🡒	Photo Points
▬	Slope Degrees
🟧	Woodland Type B
🟦	Shrubland Type C
🟪	Scrub Type D
🟨	Grassland Type G
⬚	100m Assessment Boundary
▨	Low Fuel or Non Vegetated 2_3_2_3
🟥	Subject site

SCALE
1: 2, 250 @ A3
MGA GDA 94 Zone 50

0 10 20 40 60 80 100
Meters

This BAL Contour Plan was prepared by:
Kathryn Kinnear, Bio Diverse Solutions
Accreditation No: BPAD30794
Valid to: Feb 2017
Jurisdiction: Level 1 - WA

BPAD
Bushfire
Planning & Design
Accredited Practitioner
Level 1

BIO DIVERSE SOLUTIONS

55 Peppermint Drive
Albany, WA 6330
Australia

Tel: 08 9841 3936
Fax: 08 9841 3936
Mob: 0447 555 516

CLIENT
Darling Downs Estate C/oTerranovis Pty Ltd
52 Kishorn Road
Applecross WA 6153

Vegetation Classes Map

STATUS	FILE	DATE
FINAL	TER011	8/8/2016

SECTION 1 - Vegetation Classification

All vegetation within 100m of the site / proposed development was classified in accordance with Clause 2.2.3 of AS 3959-2009. Each distinguishable vegetation plot with the potential to determine the Bushfire Attack Level is identified below.

Plot	**1**	**Classification or Exclusion Clause**	**Low fuel or non-vegetated area Clause 2.2.3.2 (f)**
			Exclusion clause 2.2.3.2 (f) Low threat vegetation, bare soil associated with bare areas of adjacent subdivision developments to the north and west of the subject site.
Photo ID: Photo 1 view of bare areas associated with the development to the west of the subject site. View from north east to south west.			
Plot	**2**	**Classification or Exclusion Clause**	**Low fuel or non-vegetated area Clause 2.2.3.2 (e)**
			Exclusion clause 2.2.3.2 (e) Low threat vegetation associated with buildings, dwellings, footpaths and roads
Photo ID: Photo2 view along Rowley Road from the west to east.			
Plot	**3**	**Classification or Exclusion Clause**	**Low fuel or non-vegetated area Clause 2.2.3.2 (f)**
			Exclusion clause 2.2.3.2 (f) Low threat vegetation associated with APZ areas adjacent to buildings and dwellings Grasses mowed and maintained <50mm in height.
Photo ID: Photo3 View of low fuel to the south of Rowley Road and dwellings (background) with maintained APZ areas. View from north to south.			

Plot	**3 cont**	**Classification or Exclusion Clause**	**Low fuel or non-vegetated area Clause 2.2.3.2 (f)**
			Exclusion clause 2.2.3.2 (f) Low threat vegetation associated with APZ areas adjacent to buildings and dwellings Grasses mowed and maintained <50mm in height.

Photo ID: Photo 4 view of low fuel areas grasses <50mm in height. View from north to south from Rowley Road.

Plot	**3 cont**	**Classification or Exclusion Clause**	**Low fuel or non-vegetated area Clause 2.2.3.2 (f)**
			Exclusion clause 2.2.3.2 (f) Low threat vegetation associated with APZ areas adjacent to buildings and dwellings Grasses mowed and maintained <50mm in height.

Photo ID: Photo 5 view of low fuel areas of a dwelling along Hilbert Road tot eh east of the subject site. View from west to east.

Plot	**4**	**Classification or Exclusion Clause**	**Woodland Type B**
			Eucalypts 6-12m Not multilayered, grassy understorey, possibly grazed 10-30% vegetative cover. Located south of the subject site 21m from subject site (along Rowley Road Road) Effective Slopes 0.4 degrees (flat land) to upslope of site.

Photo ID: Photo 6 view of Woodland Type B to the south of the Subject site, view from north west to south east.

Plot	**5**	**Classification or Exclusion Clause**	**Grassland Type G**
			Paddock grasses 50-200mm in height Not grazed in road verges, grazed in paddocks Fuel loading 2 T/ha Located adjacent to subject site to the south and west in road verges and paddocks adjacent Effective Slope 0 to 0.4 ° (degrees) Located east of Rowley Road 21m from subject site <10% trees
Photo ID: Photo 7 view of Grassland Type G to the south of the subject site in Rowley Road reserve.			

Plot	**6**	**Classification or Exclusion Clause**	**Low fuel or non-vegetated area Clause 2.2.3.2 (f)**
			Low fuel or non vegetated areas Clause 2.2.3.2 (f) Planted windbreaks
Photo ID: Photo 8 view of Planted windbreak in property to the east of the subject site. Photo view from west to east from Hilbert Road.			

Plot	**7**	**Classification or Exclusion Clause**	**Grassland Type G**
			Paddock grasses 300-400mm in height Possibly grazed, unmanaged grasses Fuel loading 2 T/ha Located adjacent to subject site to the south Effective Slope 0.4 degrees (flat land) to upslope of site. <10% trees Located 20m south of subject site.
Photo ID: Photo 9 view of Grassland Type G to the south of the subject site. View from Rowley Road from the north west to the south east.			

Plot	**8**	**Classification or Exclusion Clause**	**Grassland Type G**
			Paddock grasses 300-400mm in height Grazed, unmanaged grasses Fuel loading 2 T/ha Located adjacent to subject site to the east Effective Slope 0 degrees (flat land) to upslope of site. <10% trees Located 20m South of Subject site.
Photo ID: Photo 10 view of Grassland Type G to the south of the subject site. View from Rowley Road from the north to the south.			
Plot	**9**	**Classification or Exclusion Clause**	**Grassland Type G**
			Paddock grasses 300-400mm in height Grazed, unmanaged grasses Fuel loading 2 T/ha Located adjacent to subject site to the south east Effective Slope 0 degrees (flat land) <10% trees. Located 22.4m from eastern boundary wall.
Photo ID: Photo 11 view of Grassland Type G to the east of the site, view from west to east from Hilbert Road			
Plot	**10**	**Classification or Exclusion Clause**	**Grassland Type G**
			Paddock grasses 300-400mm in height Grazed, unmanaged grasses Fuel loading 2 T/ha Located adjacent to subject site to the north east Effective Slope 0 degrees (flat land) <10% trees. Located 41m from north east corner of subject site
Photo ID: Photo 12 view of Grassland type G to the north east of the subject site. View from Hilbert street from the west to east			

Plot	11	Classification or Exclusion Clause	Woodland Type B
			Eucalypts 6-12m Not multilayered, grassy understorey, possibly grazed 10-30% vegetative cover. Located north (north east) of the subject site 21m from subject site (along future Rowley Road Reserve) Effective Slope -upslope of site. Located 26m north of subject site. Assumption in BAL Contour this will be removed as per approved WAPC application over the area. Future Low Fuel 2.2.3.2 (e) and (f)

Photo ID: Photo 13 view of Woodland Type B to the north of Rowley Road Reserve. View from Hilbert Street from the east to the west.

Plot	12	Classification or Exclusion Clause	Shrubland Type C
			Grasses and sedges to 1m Dead vegetation and unmanaged 15T/ha available fuels Located 30m from the subject site to the north west. Effective slope - upslope

Photo ID: Photo 14 view of Shrubland Type C to the north west of the site. View from the southeast to the northwest.

Plot	13	Classification or Exclusion Clause	Scrub Type D
			Spearwood, Woolly bush and Acacia Scrub 3.0 – 4.0m in height Would be excludable as <0.25ha in size but connected to Plot 12 (shrubland) 25T/ha available fuels Located upslope of the subject site to the north west 89m. Effective slope - upslope

Photo ID: Photo 15 view of Scrub Type D to the north west of the site. View from the southeast to the northwest.

<table>
<tr><td>Plot</td><td>14</td><td>Classification or Exclusion Clause</td><td>Grassland Type G</td></tr>
<tr><td colspan="3"></td><td>Paddock grasses 300-400mm in height
Possibly grazed, unmanaged grasses
Fuel loading 2 T/ha
Located adjacent to subject site to the west in paddocks and the road reserve
Effective Slope Flat land - 0 degrees
No trees
17-24m from subject site</td></tr>
<tr><td colspan="4"><i>Photo ID: Photo 16 view of Grassland Type G to the west of the subject site. View from the north east to the south west in private property.</i></td></tr>
<tr><td>Plot</td><td>15</td><td>Classification or Exclusion Clause</td><td>Low fuel or non vegetated areas</td></tr>
<tr><td colspan="3"></td><td>Low fuel Exclusion 2.2.3.2 (f)
All internal areas, bare ground or managed grasses to <100mm</td></tr>
<tr><td colspan="4"><i>Photo ID: Photo 17 view of built up bare areas in the subject site in preparation for development. View from the north west to the south east.</i></td></tr>
</table>

SECTION 3: Potential Bushfire Impacts

The potential bushfire impact to the site / proposed development from each of the identified vegetation plots are identified below. Refer to BAL Contour Plan Page 11.

Plot	Vegetation Classification	Effective Slope	Separation (m)	BAL	:Lots affected
1	Low Fuel or non vegetated area 2.2.3.2 (f)	N/A	N/A	Low	N/A
2	Low Fuel or non vegetated area 2.2.3.2 (e)	N/A	N/A	Low	N/A
3	Low Fuel or non vegetated area 2.2.3.2 (f)	N/A	N/A	Low	N/A
4	Woodland Type B	Upslope and Flat Land	21	BAL 29-12.5 can apply	Rec reserve
5	Grassland Type G	Flat Land	21m	BAL 12.5 can apply	Rec reserve
6	Low Fuel or non vegetated area 2.2.3.2 (f)	N/A	N/A	Low	N/A
7	Grassland Type G	Upslope and Flat Land	20m	BAL 12.5 can apply	119-123 & 109-110
8	Grassland Type G	Upslope and Flat Land	20m	BAL 12.5 can apply	110-119
9	Grassland Type G	Upslope and Flat Land	22m	BAL 12.5 can apply	118, 94-99 & 173-174
10	Grassland Type G	Upslope and Flat Land	41m	BAL 12.5 can apply	172
11	Future Low Fuel or non vegetated area 2.2.3.2 (f) & (E)	N/A	N/A	Low	N/A
12	Shrubland Type C	Upslope and Flat Land	30m	BAL 12.5 can apply	143-151, 160-165
13	Scrub Type D	Upslope	89m	BAL 12.5 can apply	143
14	Grassland Type G	Upslope and Flat Land	17-24m	BAL 12.5 can apply	1144-155, 1-5
15	Low Fuel or non vegetated area 2.2.3.2 (f)	N/A	N/A	Low	N/A

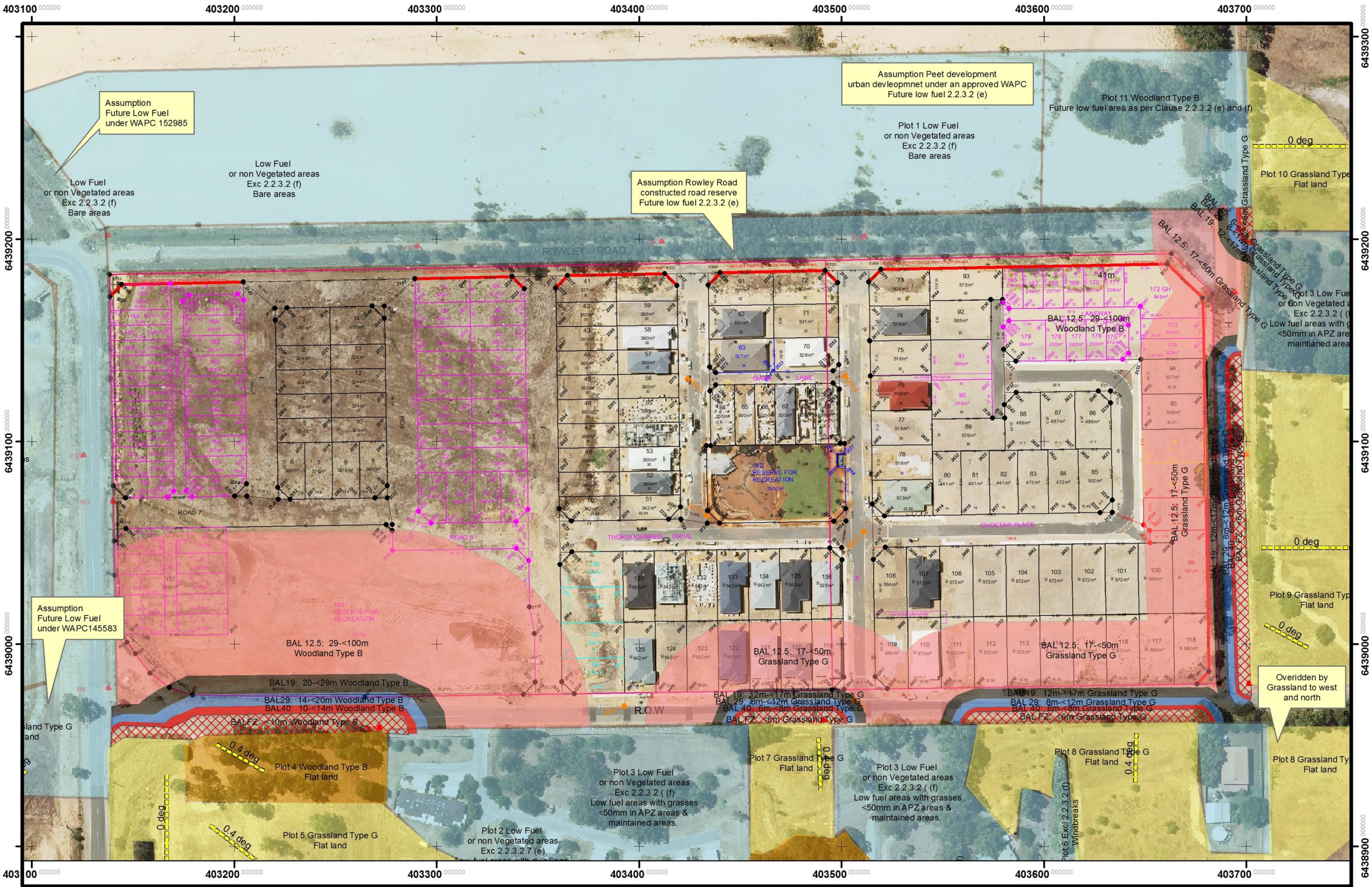
COMMENTS ON BAL CALCULATIONS:

- Distances from vegetation were made based on surface fuels to ledge of lot (subject site) boundary;
- Effective slopes were measured in the field using a Nikon Forestry Pro and represented on the respective plots;
- Method 1 (AS3959-2009) Simplified procedure was used for vegetation classification and BAL Assessment process;
- Vegetation was classified within 100m of the lot boundaries;
- The perimeter of the vegetation was measured using field GPS and notations on field GIS maps;
- The BAL Contour Plan was prepared by an Experienced Level 2 Bushfire Planning Practitioner (pending Accreditation by FPA); and

- The BAL Contour Map has been prepared in accordance with Department of Planning (WAPC) Fact Sheet – BAL Contour Maps (Version 2, January 2016).

ASSUMPTIONS

- Internal areas of the subdivision will be maintained in a low fuel state (as per APZ standards and AS3959-02009 Clause 2.2.3.2 (f)) by the developer until individual lot construction occurs.
- Rowley Road to the north is proposed to be developed within 12 months and construction will involve the resulting road reserve to be in a low fuel state consistent with AS3959-2009 Clause 2.2.3.2 (f).
- The land north of the future Rowley road is under an approved WAPC subdivision application and urban development is progressing, this area is designated as future low fuel area as per AS3959-2009 Clause 2.2.3.2 (e) and (f)
- The land north west of the subject site is under an approved WAPC subdivision application (WAPC # 152985) and urban development is progressing, this area is designated as future low fuel area as per AS3959-2009 Clause 2.2.3.2 (e) and (f)
- The land south west of the subject site is under an approved WAPC subdivision application (WAPC b# 145583) and urban development is progressing, this area is designated as future low fuel area as per AS3959-2009 Clause 2.2.3.2 (e) and (f)



Legend

▬ Slope Degrees	🟥 BAL 12.5
🟪 Scrub Type D	⬛ BAL 19
🟧 Woodland Type B	🟦 BAL 29
🟨 Grassland Type G	🟥 BAL 40
▨ BAL FZ	
🟦 Low Fuel or Non Vegetated 2_3_2_3	

SCALE
1: 1, 750 @ A3
MGA GDA 94 Zone 50

0 10 20 40 60 80 100
Meters

This BAL Contour Plan was prepared by:
Kathryn Kinnear, Bio Diverse Solutions
Accreditation No: BPAD30794
Valid to: Feb 2017
Jurisdiction: Level 1 - WA

BPAD
Bushfire
Planning & Design
Accredited Practitioner
Level 1

BIO DIVERSE SOLUTIONS

55 Peppermint Drive
Albany, WA 6330
Australia
Tel: 08 9841 3936
Fax: 08 9841 3936
Mob: 0447 555 516

CLIENT
Darling Downs Estate C/oTerranovis Pty Ltd
52 Kishorn Road
Applecross WA 6153

BAL Contour Plan

STATUS	FILE	DATE
FINAL	TER011	8/8/2016

SECTION 4: DISCLAIMER

The recommendations and measures contained in this assessment report are based on the requirements of the Australian Standards 3959-2009 – Building in Bushfire prone Areas, WAPC State Planning Policy 3.7 (WAPC, 2015), WAPC Guidelines for Planning in Bushfire Prone Areas (WAPC, 2015), and CSIRO's research into Bushfire behaviour. These are considered the minimum standards required to balance the protection of the proposed dwelling and occupants with the aesthetic and environmental conditions required by local, state and federal government authorities. They DO NOT guarantee that a building will not be destroyed or damaged by a bushfire. All surveys and forecasts, projections and recommendations made in this assessment report and associated with this proposed dwelling are made in good faith on the basis of the information available to the fire protection consultant at the time of assessment. The achievement of the level of implementation of fire precautions will depend amongst other things on actions of the landowner or occupiers of the land, over which the fire protection consultant has no control. Not withstanding anything contained within, the fire consultant/s or local government authority will not, except as the law may require, be liable for any loss or other consequences (whether or not due to negligence of the fire consultant/s and the local government authority, their servants or agents) arising out of the services rendered by the fire consultant/s or local government authority.

AS3959-2009 disclaimer: It should be borne in mind that the measures contained within this Standard (AS3959-2009) cannot guarantee that a building will survive a bushfire event on every occasion. This is substantially due to the unpredictable nature and behaviour of fire and extreme weather condition.
(AS3959, 2009)

Building to AS39590-2009 is a standard primarily concerned with improving the ability of buildings in designated bushfire prone areas to better withstand attack from bushfire thus giving a measure of protection to the building occupants (until the fire front passes) as well as to the building itself.

SECTION 7: Certification

I hereby certify that I have undertaken the assessment of the above site and determined the Bushfire Attack Level stated above in accordance with the requirements of AS 3959-2009 (Incorporating Amendment Nos 1, 2 and 3).

SIGNED, ASSESSOR: .... DATE: 8/8/2016

Kathryn Kinnear, Bio Diverse Solutions
Accredited Level 1 BAL Assessor (Accreditation No: BPAD30794)
"Experienced" Level 2 and 3 Bushfire Practitioner pending accreditation.

BIO DIVERSE SOLUTIONS

BPAD
Bushfire
Planning & Design
Accredited Practitioner
Level 1

Appendix 2: – Additional Information / Advisory Notes / Justifications Related to Assessment

Vegetation types analysed to A3959-2009 with the following justifications:

Vegetation Woodland Type B
- Not multi-layered vegetation structure;
- Surface fuels and could reach 15-25T/ha surface fuels;
- <30% vegetative structure/cover; and
- Eucalypt Trees 8-15m

Shrubland Type C
- Shrubs to 1m;
- 15T/ha available fuel loading;
- Dominated by grasses and sedges; and
- No to few trees

Scrub Type D:
- Acacia, Spearwood, Melaleuca scrubs 2-3m;
- Dense single layer of fuels;
- No to few trees >4m; and
- Some understorey grasses, mainly midstorey and scrub species to 2.5-3m.

Grassland Type G
- Unmanaged grasslands – not regularly slashed or grazed;
- Average heights of grasses 50-250mm
- Dominated by grass species; and
- <10% tree/scrub species present.

Low Fuel and non-vegetated areas (AS3959-2009 2.2.3.2):

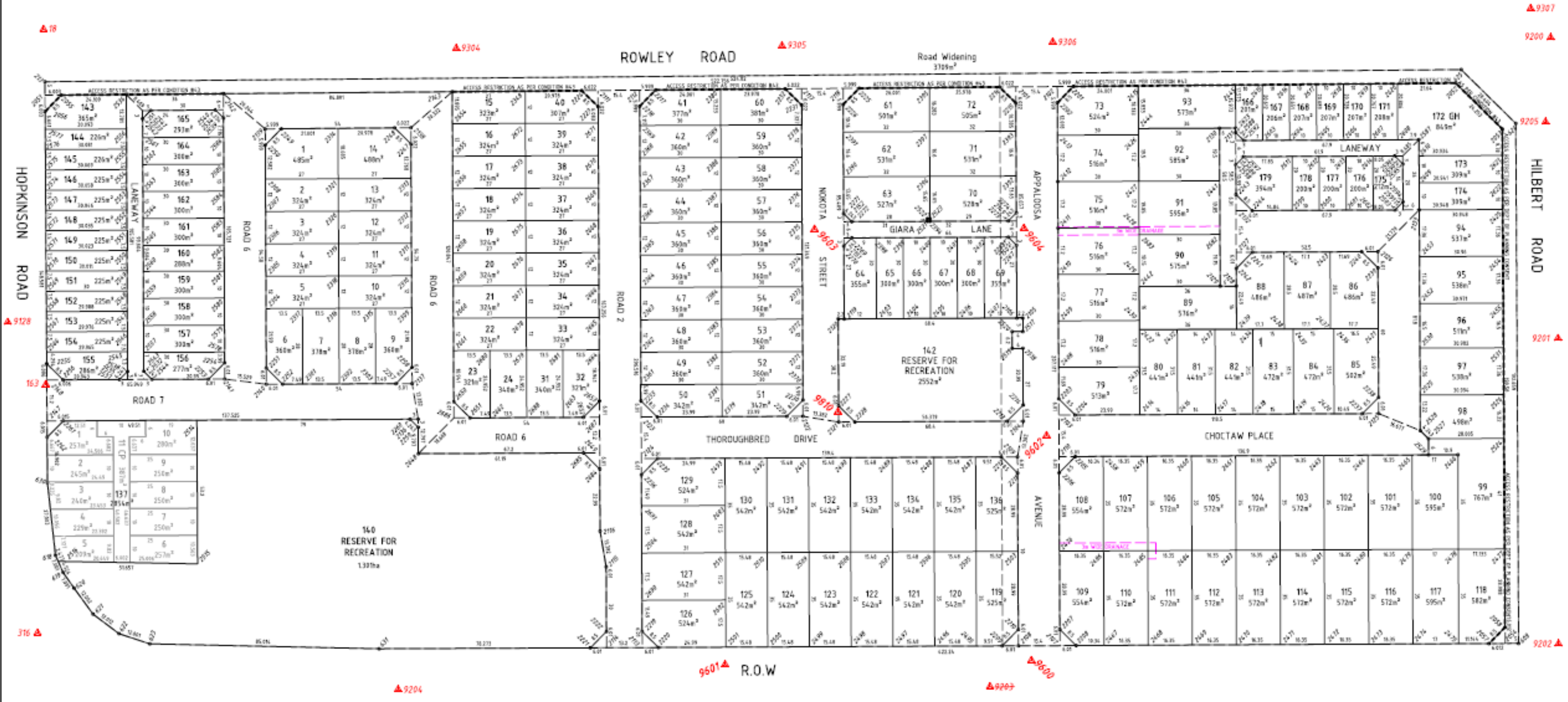
Clause (e) – Non-vegetated areas, including waterways, roads, footpaths, buildings and rocky outcrops.
- Footpaths;
- Buildings;
- Bare ground;
- Carparks; and
- Roads

Clause (f) – Low threat vegetation including managed grassland in minimal fuel condition, maintained lawns, golf courses, maintained public reserves and parklands, vineyards, orchards, cultivated ornamental gardens, commercial nurseries, nature strips and wind breaks.
- Low fuel areas associated with managed grasslands, ornamental gardens in APZ areas of established buildings/dwellings.
- Managed grasses <100mm in height, evidence of regular mowing.

BAL Assessment undertaken by an Experienced Level 2 Bushfire Practitioner. Method 1 AS3959-2009 applied for BAL Assessment.

OBRM BUSHFIRE PRONE MAPPING 8/12/15 & 20/5/2016

https://maps.slip.wa.gov.au/landgate/bushfireprone/



Surround Control - PCG94				
Pt No	Easting	Northing	RL	Description
18	64,699.585	238,232.422	25.727	MAG 18
163	64,700.436	238,100.877	26.035	BM FS63
316	64,697.345	238,008.800	26.349	SPK
9127	64,687.534	237,884.759		SPK
9128	64,686.323	238,123.901		SIP
9200	65,258.020	238,229.328		SIP
9201	65,260.724	238,117.910	27.295	SIP
9202	65,260.968	238,004.735	27.799	SIP
~~9203~~	~~65,050.316~~	~~237,988.912~~	~~26.986~~	~~SIP~~
9204	64,830.942	237,987.826	26.635	SIP
9205	65,256.125	238,198.109		DSPK IN BIT
9304	64,852.500	238,225.394	26.500	DSPK IN BIT
9305	64,973.196	238,226.325	26.649	DSPK IN BIT
9306	65,073.543	238,227.752	26.750	DSPK IN BIT
9307	65,250.640	238,240.160	27.716	HILTI IN M/H SURROUND
9309	65,254.211	238,709.901	26.978	DSPK IN BIT

SSA Control - PCG94				
Pt No	Easting	Northing	RL	Description
9600	65,065.617	237,998.672	27.292	HILTI IN RBEAM
9601	64,952.132	237,997.102	27.085	HILTI IN RBEAM
9602	65,071.261	238,081.957	28.025	HILTI IN RBEAM
9603	64,985.273	238,158.408	28.181	SPK IN BIT
9604	65,062.846	238,158.774	28.032	SPK IN BIT
9810	64,993.954	238,090.763	27.823	PLAQUE

SCALE 1/1000

10 0 10 20 30 40 50

ALL DISTANCES ARE IN METRES

6	Add SSA Control Stage 1	TRM	10/06/15	SPT
5	Amend Lots 15-26, 31-40, 90, 91 & 140. Add 143-179	TRM	24/04/15	SPT
4	Amend Lots 96 & 97.	TRM	04/12/14	SPT
3	Amend Lots 97-99. Add Access Restrictions	TRM	20/11/14	SPT
2	Amendment to lots 63 & 142	TCH	29/07/14	SPT
1	Amend Lots 126-129	SPT	20/08/13	SPT
Rev.	Description	Drawn	Date	Chkd

Surround Date: 14/11/2012
Survey Manager: RL
Drawn Date: 18/12/2013
Calc/Drafted: TCH/TCH
Scale (A2): 1: 1000
WAPC No: #####
Hor Datum: PCG'94
Vert Datum: AHD

Data File: 16086 rowleyrd-9-150820
CAD File: fp16086-002-r7.dgn
Upload File: fp16086-002-r7.crd
Path: s:\projects\ 16\ 16086\

whelans

Suite 4, First Floor, 40 Hasler Road, Osborne Park WA 6017
PO Box 99, MOUNT HAWTHORN WA 6915
T: 08 6241 3333 F: 08 6241 3300
E: whelans@whelans.com.au W: www.whelans.com.au

Client: TERRANOVIS

PRECALCULATION PLAN

ROWLEY ROAD
DARLING DOWNS
LOTS 1 & 2 on Dia 50969

16086 - 000 - 002 - 07
Job No Item No Plan No Rev

Checklist for proposal compliance and justification to SPP3.7 (2015)
& Guidelines for Planning in Bushfire Prone Areas (2015))

BDS Project Name	BAL Contour Plan Rowely Road (Lots 1 & 2 on Dia 50969)		
BDS Job Number	TER011		
Date	15/7/2016	**WAPC#**	N/A
Client name	Terranovis	**Condition #**	N/A
Bushfire Prone Area	Yes (see attached)	**Mapping**	Yes see attached
Planning proposal	Subdivision application	**Lots created**	175

1. Bushfire Protection Criteria Acceptable Solutions as defined by Guidelines for Planning for Bushfire Prone Areas (WAPC 2015).

Element	**Compliant to Acceptable Solution– Yes/No**	**Justification**
Element 1 – Location	Yes	Site has areas which are classified as low and moderate bushfire hazards. Low and moderate hazards are located to the north west, west, south, east and north east (Shrubland Type C, Grassland Type G, Woodland Type B). Proposed buildings can be in BAL 12.5 zones. **Plan of subdivision is deemed to meet Acceptable Solutions for Element 1.**
Element 2 - Siting and design of development	Yes	A2.1: 20m APZ can be achieved within the proposed lots and within the parent lot or by use of low fuel areas such as roads. A2.2 Setbacks and building to BAL/AS3959-2009 can be achieved on all lots. No higher BAL allocation than BAL 12.5 to apply to proposed lots. **Plan of subdivision is deemed to meet Acceptable Solutions for Element 2.**
Element 3 - Vehicular access	Yes	A3.1: Three access routes to the north, west and south (Rowley Road, Hopkinson Road and Rowley Road (South). A3.2 Public roads to meet minimum grades A3.3 Cul-de-sacs proposed and meet minimum requirements A3.4 Battle axes not proposed A3.5 Private Driveways will meet minimum requirements A3.6 No EAW proposed, use the internal road network A3.7 No FSA proposed, use the internal road network A3.8 Firebreaks compliant by current owner **Deemed to meet Acceptable Solutions for Element 3.**
Element 4 – Water	Yes	Connected to reticulated water, hydrants to WCWA standards. **Deemed to meet Acceptable Solutions for Element 4.**
Bushfire Hazard Assessment required	Yes	See Vegetation Classes Plan
BAL Contour required	Yes	See attached BAL Contour Map.
BMP required	No	Not deemed required

2. Policy measures SPP3.7		
Policy Measure	**Applicable – Yes/No**	**Justification**
6.1 - Higher order strategic planning documents in bushfire prone areas	No	Not a higher order strategic plan
6.2 – Strategic planning proposals, subdivision and development applications:	Yes	a) Subdivision proposal within a designated bushfire prone area, BAL and AS3959-2009 to apply to lots. Dwellings to be built to AS3959-2009 applying Acceptable Solutions, BAL 12.5 applied in newly created lots. Internal POS Low fuel areas.
6.3 - Information to accompany strategic planning proposals:	Yes	a) Results of the BHL in accordance with the detailed methodology in Guidelines and prepared by an accredited practitioner. b) BAL contour plan provided (see attached) BAL 12.5 can apply to lots. c) Brief assessment to Bushfire Protection Criteria (Elements) in the Guidelines indicated can meet the elements by applying Acceptable Solutions.
6.4 - Information to accompany subdivision application	Yes	a) BAL Contour map showing indicative BAL Contours across the subject site in accordance with the guidelines. b) BAL Contour Map prepared by an accredited Level 1 Bal Assessor and Experienced Level 2 Bushfire Practitioner. c) Brief assessment to Bushfire Protection Criteria (Elements) as per the Guidelines indicated can meet the elements by applying Acceptable Solutions
6.5 Information to accompany Development applications	No	Not applicable – not a Development Application
6.6 Vulnerable or high-risk land uses	No	No vulnerable or high risk uses proposed.
6.7 Strategic Planning proposals, subdivision or development applications in areas where an extreme BHL and/or BAL-40 or BAL –FZ applies	No	Not applicable
6.8 Advice of State/relevant authorities for emergency services sought	No	Not deemed required
6.9 Advice of State/relevant agencies/authorities for environmental protection to be sought	No	Not deemed required.
6.10 Bushfire conditions may be imposed	Yes	Yes, recommend notification on any new titles that building to AS3959-2009 to apply to any new buildings.
6.11 Precautionary principle	No	Not applied

3. Recommendations based on above checklist

1. Assessment to SPP3.7 Indicates that the subdivision has Moderate and Low BHLs to the north west, west, south, east and north east (Shrubland Type C, Grassland Type G, Woodland Type B) external to the site. Internal areas low fuel and maintained by the developer
2. BAL 12. can be achieved in the proposed lots.
3. Brief assessment to Guidelines indicated can meet the Elements by applying Acceptable Solutions can be achieved in the subsequent stages.
4. Detailed BMP not deemed required.
5. BAL Contour Plan based on assumptions that Rowley Road reserve will be built within the next 12 months.
6. Notification on title for newly created lot as condition of subdivision, building to AS3959-2009 to apply to any new dwellings.
7. Bushfire prone area mapping is correct as per the Map of Bush Fire Prone Areas identifying land falling within, or partially within, a bush fire prone area of Western Australia as designated by the Fire and Emergency Services (FES) Commissioner dated 8/12/2015 and 21/5/2016. Updates of this mapping will occur at the discretion of the FES Commissioner and the BAL Contour Mapping is considered valid for a period of 12 months from the date of production.

Prepared by:

Kathryn Kinnear, Bio Diverse Solutions

Accredited Level 1 BAL Assessor (Accreditation No: BPAD30794)

Experienced Level 2/3 BAL Assessor (Pending Accreditation)

BPAD
Bushfire
Planning & Design
Accredited Practitioner
Level 1

Disclaimer

The recommendations and measures contained in this assessment report are based on the requirements of the Australian Standards 3959 – 2009 Building in Bushfire prone Areas, Guidelines for Planning for Bushfire Prone Areas (WAPC, 2015), WA State Planning Policy 3.7 (WAPC, 2015) and CSIRO's research into Bushfire behaviour. These are considered the minimum standards required to balance the protection of the proposed dwelling and occupants with the aesthetic and environmental conditions required by local, state and federal government authorities. They DO NOT guarantee that a building will not be destroyed or damaged by a bushfire. All surveys and forecasts, projections and recommendations made in this assessment report and associated with this proposed dwelling are made in good faith on the basis of the information available to the fire protection consultant at the time of assessment. The achievement of the level of implementation of fire precautions will depend amongst other things on actions of the landowner or occupiers of the land, over which the fire protection consultant has no control. Notwithstanding anything contained within, the fire consultant/s or local government authority will not, except as the law may require, be liable for any loss or other consequences (whether or not due to negligence of the fire consultant/s and the local government authority, their servants or agents) arising out of the services rendered by the fire consultant/s or local government authority.

References

Western Australian Planning Commission (WAPC) (2015) Guidelines for Planning in Bushfire Prone Areas. Western Australian Planning Commission and Department of Planning WA, Government of Western Australia.

Western Australian Planning Commission (WAPC) State Planning Policy 3.2 Planning in Bushfire Prone Areas. Department of Planning WA and Western Australian Planning Commission.

State Land Information Portal (SLIP) (2015 & 2016) map of Bushfire Prone Areas. Office of Bushfire Risk management (OBRM) data retrieved from:

https://maps.slip.wa.gov.au/landgate/bushfireprone/

APPENDIX 5

TRANSPORT TECHNICAL NOTE NO. 6

61 York Street
Subiaco WA 6008
P.O.Box 42 Subiaco WA 6904
Phone: +61 (08) 9382 4199
Fax: +61 (08) 9382 4177
Email: admin@transcore.net.au
transport planning • traffic engineering • transport modelling
TRANSCORE PTY LTD ACN 094 951 318 ABN 19 094 951 318

Technical Note: No. 6	Date: 7/09/2016
Project No: t16.173	
Project: Lots 1 & 2 Rowley Rd, Darling Downs	
Subject: **Deletion of Hopkinson Road Access Street Intersection**	

1. INTRODUCTION

Transcore Pty Ltd has been commissioned by Darling Downs Estate Pty Ltd to provide traffic engineering services in relation to clearance of subdivision approval conditions for the subdivision at Lots 1 & 2 Rowley Road, Darling Downs (referred to as the Darling Downs Estate or the subject site in this technical note) and to review the future road and intersection requirements on the adjacent road network.

Technical Note No 5 evaluated the ultimate and interim intersection requirements for the proposed access street intersection into the subject site on the eastern side of Hopkinson Road.

Technical Note No 6 considers the alternative option of not constructing the Hopkinson Rd access street intersection at all and evaluates the effects this would have elsewhere within the Darling Downs Estate.

2. APPROVED SUBDIVISION

The approved subdivision for the Darling Downs Estate (Application 145280) and the planned stages of subdivision development are illustrated in **Figure 1**.

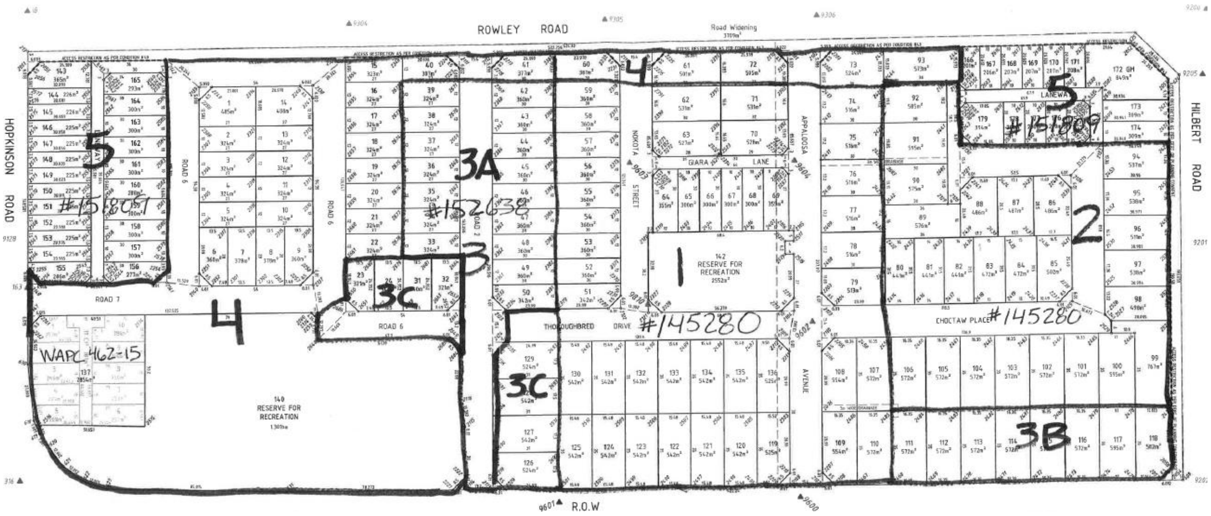


Figure 1: Subdivision stages

3. ALTERNATIVE CONCEPT PLAN

The alternative option under consideration in this Technical Note would not provide vehicular access direct from the subject site to Hopkinson Rd. Instead that road reserve would be used for visitor parking and pedestrian / cyclist access, as shown in **Figure 2**.

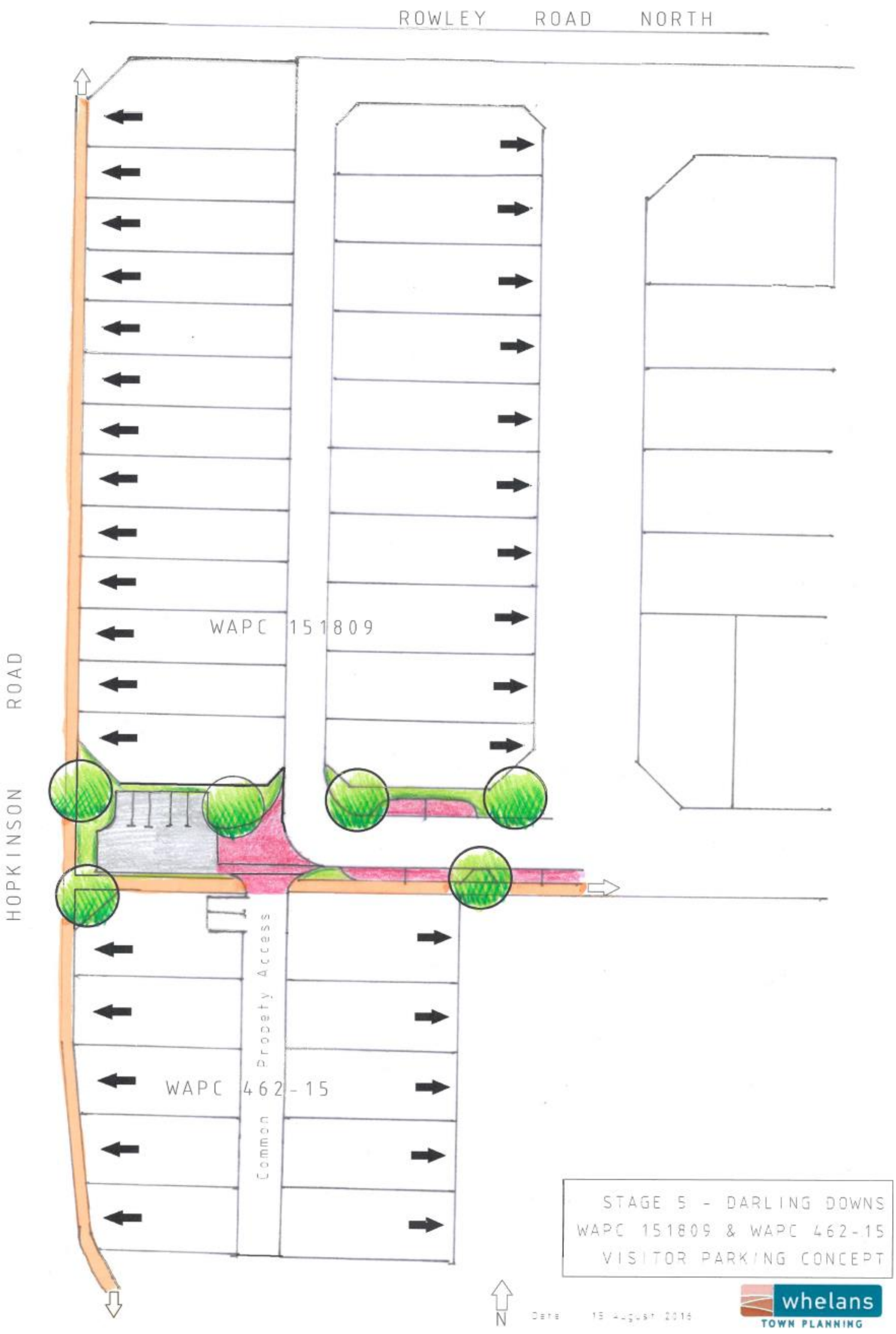


Figure 2: Concept plan without Hopkinson Rd access intersection

4. FUTURE TRAFFIC FLOWS

Transcore's Armadale strategic traffic model (Scenario 1002) draft results were provided to the City of Armadale on 9 August 2016.

That traffic model indicates a 2031 traffic distribution from Darling Downs Estate as follows:

- 56% to/from the west (Rowley Rd North);
- 29% to/from the east (Rowley Rd South);
- 13% to/from the north (Hopkinson Rd); and
- 2% to/from the south (Hopkinson Rd).

The Darling Downs Estate is represented as one zone in that strategic traffic model so a more detailed subarea traffic model has been developed to model the Darling Downs Estate in sufficient detail to evaluate the effect of localised options such as the deletion of the planned access street intersection on Hopkinson Road.

The subarea model is based on the traffic generation rate of 8 vpd per dwelling that has previously been agreed with MRA and the City of Armadale for the Wungong Urban Water Master Plan (WUWMP) area. Therefore the 177 residential lots shown on the subdivision plan at **Figure 1** would generate total daily traffic flows of approximately 1400vpd. The subarea traffic model assigns this traffic onto the local road network based on the traffic distribution listed above.

For comparison, the modelled daily traffic flows within and adjacent to the subject site are shown in **Figure 3** with a left in / left out (LILO) intersection at the access street on Hopkinson Rd and **Figure 4** with no access street intersection on Hopkinson Rd.

The total daily traffic flows (nominally year 2031 with full development of the WUWMP area) are based on the Armadale traffic model flows with manual adjustment to reflect the localised traffic flow variations associated with these options for Darling Downs Estate.

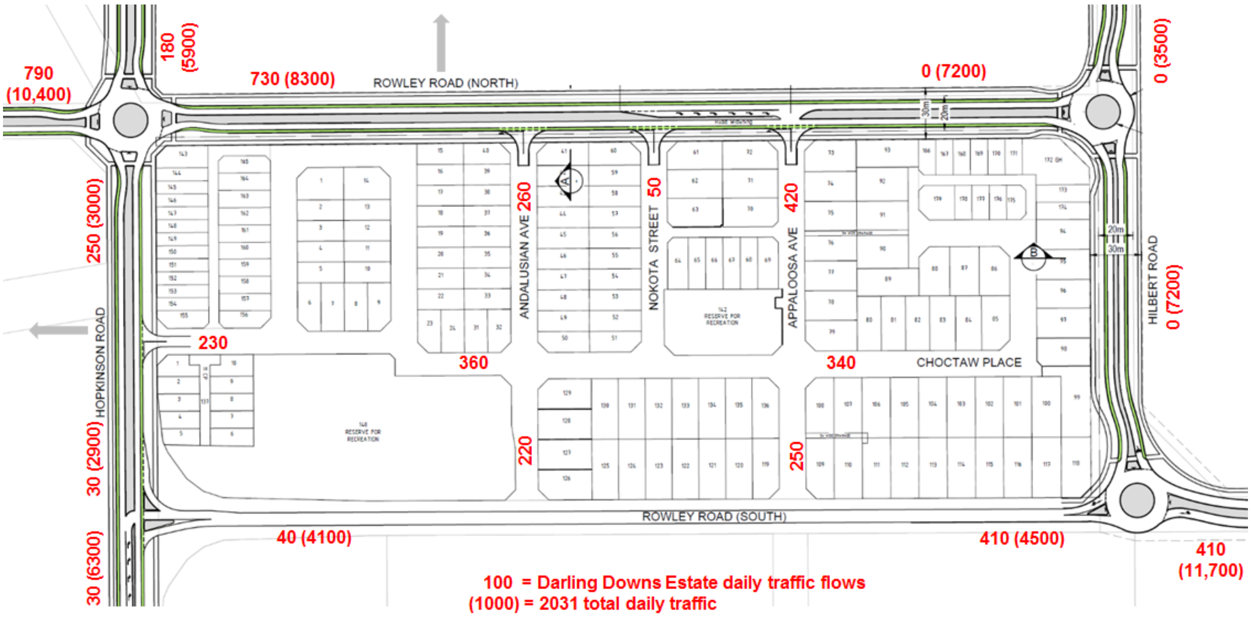


Figure 3: Future daily traffic flows with LILO Hopkinson Rd access street intersection

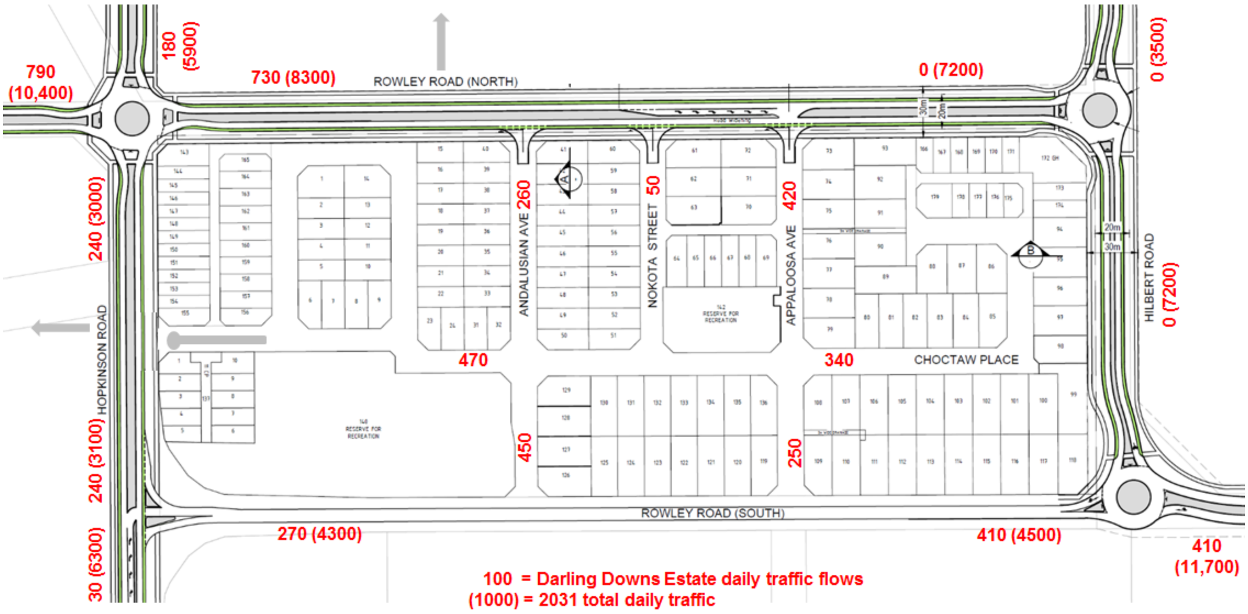


Figure 4: Future daily traffic flows without Hopkinson Rd access street intersection

Comparison of Figures 3 and 4 indicates that the only change resulting from deletion of the access street intersection on Hopkinson Road would be reassignment of 230vpd slightly further to the south via Hopkinson Rd – Rowley Rd (South) – Andalusian Ave.

This change in traffic flows does not significantly alter the total traffic flows on these sections of road.

All of the internal access streets within the Darling Downs Estate will carry traffic flows less than 1000vpd in both options. Therefore the minimum road standard for these access streets in the WAPC Liveable Neighbourhoods policy would be Access Street D (6m road carriageway in a 14.2m road reserve) in both options.

It should be noted that the alternative route available (via Rowley Rd (North) then turn right into Appaloosa Ave) would be slightly longer for the affected traffic flow but may still be chosen by some drivers. However the number of vehicles that might use this alternative are low (probably less than half of the affected 230vpd) and would not alter the overall conclusions of this analysis.

7. CONCLUSIONS

In conclusion, therefore, the option of not connecting the western access street to Hopkinson Rd would not have a significant impact on traffic flows within the Darling Downs Estate or on the adjacent road network and would not alter the required road standards within or adjacent to the Darling Downs Estate.

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Addendum 1

Structure Plan Amendment No. 2

Certification of Approved Structure Plan

Amendment No. 2

This Structure Plan is prepared under the provisions of the
Shire of Serpentine Jarrahdale Town Planning Scheme No. 2
and in accordance with the
Planning and Development (Local Planning Schemes) Regulations 2015

IT IS CERTIFIED THAT THIS STRUCTURE PLAN
WAS APPROVED BY RESOLUTION OF
THE WESTERN AUSTRALIAN PLANNING COMMISSION ON:

……………………………………
Date

Signed for and on behalf of the Western Australian Planning Commission

……………………………………………………………………………………………………

An officer of the Commission duly authorised by the Commission pursuant to section 16 of the *Planning and Development Act 2005* for that purpose, in the presence of:

……………………………………………………………………………………………………
Witness

…………………………………………………………
Date

……………………………………………
Date of Expiry of this Structure Plan

Amendment No. 2

Pre-lodgement Consultations

Amendment No. 2 proposes to re-code an 4,454m2 area of the structure plan from R40 to R20.

Under WAPC 151809 the 4,454m2 portion in the north-east area of the structure plan was proposed to be subdivided into 14 lots, providing a potential yield of 15 dwellings (including grouped dwellings on proposed Lot 172). Figure 1 shows the proposed lots under WAPC 151809. Figure 2 shows a potential R20 subdivision for six lots over the 4,454m2 area, yielding six single dwellings.

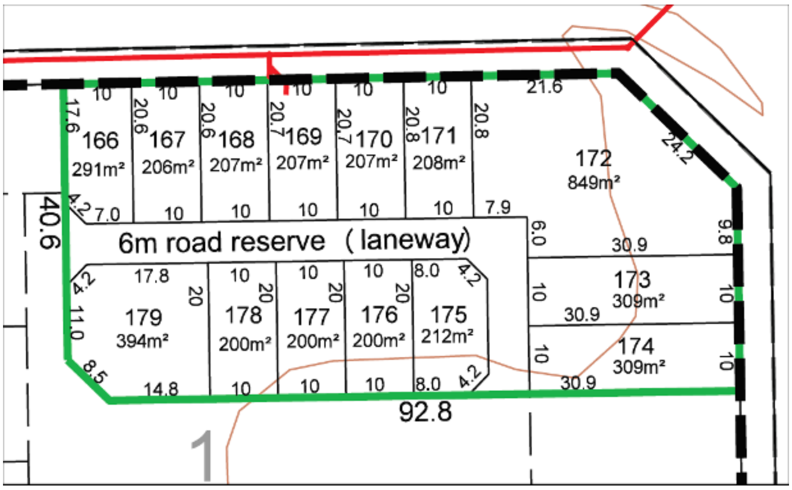


Figure 1. Extract from WAPC 153809 approved subdivision plan.

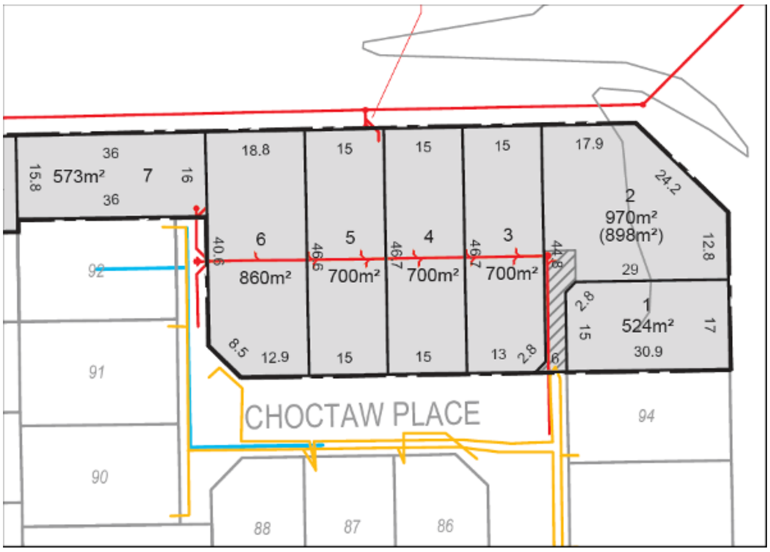


Figure 2. Potential R20 subdivision design

Table 1 below is a summary of pre-lodgement discussions with the Department of Planning, Lands and Heritage, Shire of Serpentine Jarrahdale and other agencies based on the re-coding planning outcome in Figure 2.

Table 1. Summary of pre-lodgement consultations for Amendment No. 2

Agency	Date of Consultation	Method of Consultation	Summary of Outcome
Shire of Serpentine Jarrahdale	February 2020	Emails	**Bushfire Management** An updated Bushfire Management Plan will need to be provided demonstrating the north-east area can be developed. When the original Bushfire Management Plan was approved, Rowley Road North was a managed road but this is no longer the case and therefore an updated BMP will be required. **Structure Plan Density** Shire confirmed the need for a structure plan amendment to formalise the reduction in density. The proposed single dwelling subdivision layout produced by the Proponent could result in future unplanned, ad hoc subdivision in undesirable battle-axe configurations if the R40 density coding under the structure plan were to remain.
Department of Planning, Lands & Heritage	March 2020	Meeting	DPLH officers confirmed the re-coding from R40 to R20 could be supported in-principle. The formatting for the structure plan amendment documentation should be as simple as possible, potentially following the format adopted by Metro South – Peel for Anketell North Structure Plan for consistency.
Water Corporation	February 2020	Email/ Telephone	Water Corporation in-principle support and confirmation of feasibility to service the proposed development from Choctaw Place and the decommissioning of existing sewer infrastructure extending through the subject area.

Changes to Residential Development Yield

As a result of the re-coding from R40 to R20 a revised dwelling estimate is provided as follows:

Current Approved Structure Plan Dwelling Yield	
WAPC 151809, 152638, 153900 & 462-15 subdivision & survey strata applications	179 dwellings
Amendment No. 2 Structure Plan Dwelling Yield	
Under future staged subdivision	170 dwellings

Table 2 provides development statistics which can be used to measure the performance of the structure plan (and above subdivision dwelling yield) against the key target outcomes of Directions 2031 and Liveable Neighbourhoods.

Table 2 Estimated Development Yield for Structure Plan

	Site Outcomes	Target Density
Total SP Landholdings Area	11.4474 hectares	-
Area set aside for roads, drainage & POS	3.18 hectares	-
Balance area for residential development	8.25 hectares	-
Estimate ultimate number of dwellings	170 dwellings	-
Estimated number dwellings per site hectare[1]	20 dwellings/ha	**Liveable Neighbourhoods** 12 – 20 dwellings per site hectare for standard lot layouts 20 – 30 dwellings per site hectare for lots within proximity to activity centres
SP target density per gross urban hectare[2]	15 dwellings/site ha	**Directions 2031** 15 dwellings per gross urban hectare

[1] Liveable Neighbourhoods definition of site hectare is the area available for residential development excluding roads, non-residential uses, public open space and drainage areas.

[2] Directions 2031 definition of gross urban hectare is the gross area available for urban development

The structure plan delivers approximately 20 dwellings per site hectare, which is consistent with Liveable Neighbourhoods density expectations for the site's locational context.

Similarly, the structure plan delivers approximately 15 dwellings per gross urban hectare, which is consistent with the target density of 15 dwellings per gross urban hectare under Directions 2031. Approximately 476 persons (based on average 2.8 persons per dwelling) are expected to live within the structure plan area.

Public Open Space

There is no change to the approved structure plan public open space area of 1.363 hectares (12.5%).

Bushfire Management

The re-coding from R40 to R20 will have no impact on the approved structure plan bushfire management plan. To address State Planning Policy 3.7 'Planning in Bushfire Prone Areas' a Bushfire Attack Level (BAL) assessment has been prepared to inform a potential R20 subdivision.

The BAL assessment shows that certain northern portions of R20 lots will be impacted by bushfire hazard vegetation in Rowley Road (North) road reservation, resulting in BAL ratings exceeding BAL-29. However, the R20 lots are large enough (i.e. lot depth 46m) to allow for a dwelling to be constructed within the southern half where the BAL level is less than BAL-29.

Accordingly the constraints of bushfire can be adequately addressed. In addition, at some future point the vegetation in Rowley Road (North) road reserve will be cleared when the road is constructed.

Refer to Appendix 1 – Bushfire Management Plan

Appendix 1

Bushfire Management Plan

SMITH BUSHFIRE CONSULTANTS Pty Ltd

BUSHFIRE MANAGEMENT PLAN

Lot 9003 Rowley Road, Darling Downs
Shire of Serpentine Jarrahdale

BPAD
Bushfire
Planning & Design
Accredited Practitioner
Level 2

Prepared by Ralph Smith
BPAD 27541
smith.consulting@bigpond.com
0458 292 280
Site visited 3 August 2020; Report completed 19 August 2020

Bushfire management plan/Statement addressing the Bushfire Protection Criteria coversheet

Site address: Lot 900 Rowley Road, Darling Downs

Site visit: Yes ☑ No ☐

Date of site visit (if applicable): Day 3 Month August Year 2020

Report author: Ralph Smith

WA BPAD accreditation level (please circle):

Not accredited ☐ Level 1 BAL assessor ☐ Level 2 practitioner ☑ Level 3 practitioner ☐

If accredited please provide the following.

BPAD accreditation number: 27541 Accreditation expiry: Month August Year 2021

Bushfire management plan version number: 1

Bushfire management plan date: Day 19 Month August Year 2020

Client/business name: Terranovis Pty Ltd

	Yes	No
Has the BAL been calculated by a method other than method 1 as outlined in AS3959 (tick no if AS3959 method 1 has been used to calculate the BAL)?		✓
Have any of the bushfire protection criteria elements been addressed through the use of a performance principle (tick no if only acceptable solutions have been used to address all of the bushfire protection criteria elements)?		✓

Is the proposal any of the following (see SPP 3.7 for definitions)?	Yes	No
Unavoidable development (in BAL-40 or BAL-FZ)		✓
Strategic planning proposal (including rezoning applications)	✓	
Minor development (in BAL-40 or BAL-FZ)		✓
High risk land-use		✓
Vulnerable land-use		✓

None of the above ☐

Note: Only if one (or more) of the above answers in the tables is yes should the decision maker (e.g. local government or the WAPC) refer the proposal to DFES for comment.

Why has it been given one of the above listed classifications (E.g. Considered vulnerable land-use as the development is for accommodation of the elderly, etc.)?

There will be students and other groups utilising the facilities across the year.

The information provided within this bushfire management plan to the best of my knowledge is true and correct:

Signature of report author

Date 19 August 2020

Table of Contents

List of Figures

List of Appendices

Full Content Detail

Document control

Report Version	Purpose	Author/reviewer and accreditation details	Date Submitted
1	Support for the LSP amendment	Ralph Smith	19 August 2020

DISCLAIMER

This Bushfire Management Plan has been prepared in good faith. It is derived from sources believed to be reliable and accurate at the time of publication. Nevertheless, this plan is distributed on the terms and understanding that the author is not responsible for results of any actions taken based on information in this publication or for any error or omission from this publication.

Smith Bushfire Consultants Pty Ltd has exercised due and customary care in the preparation of this Bushfire Management Plan and has not, unless specifically stated, independently verified information provided by others.

Any recommendations, opinions or findings stated in this report are based on circumstances and facts as they existed at the time Smith Bushfire Consultants Pty Ltd performed the work. Any changes in such circumstances and facts upon which this document is based may adversely affect any recommendations, opinions or findings contained in this plan.

Section 1: Proposal Details

The proposal is to amend the Local Structure Plan (LSP). The Shire of Serpentine Jarrahdale has advised the proponent that the proposal does not address the Acceptable Solutions 3.1 and 3.3 of the *Guidelines for Planning in Bushfire Prone Areas*. The Guidelines were not applicable at the time of the approved LSP. The LSP is still approved and the Guidelines state that they are not retrospective (section 2.2).

Specifically, the following requires consideration as it pertains to the proposed LSP amendment 2 application:

- Choctaw Place was approved as a long cul-de-sac under the original *Lots 1 & 2 Rowley Road Structure Plan 2012*. This approval predates the SPP 3.7 and Guidelines. There was effectively no bushfire planning framework at the time for this location when it was approved.
- Choctaw Place was subsequently constructed under WAPC subdivision approval in 2013.
- A secondary access route cannot be provided to Rowley Road (North) or Hilbert Road from Choctaw Place, as the road planning for Rowley Road upgrade and Hilbert Road does not provide for a new secondary access route connection.
- The bushfire issue of a secondary emergency access should not apply in this instance as:
  - the development has only a portion formally declared as bushfire prone.
  - It is highly unlikely Choctaw Place would be cut off from bushfire as it is surrounded by residential development with low fuel loading/hazard, being grassland that is managed to ‘low threat vegetation’.
  - Choctaw Place connects with internal subdivision roads, which will ultimately provide alternative routes onto Rowley Road (South) and Hopkinson Road.
  - The proposed subdivision is part of pioneering staging of urban development in the area. Urban staging must permit temporary interim limited access options, due to the nature of the staging of development. This is seen when considering where other surrounding urban developments are also being staged –which do not have secondary access in compliance with the current bushfire framework.
- The current bushfire framework should not be retrospectively imposed on the lots which are accessed via Choctaw Place.

If an emergency access way is required it is proposed that the access will be a continuation of Choctow Place through to the old Rowley Road. The old Rowley Road, which is bitumen, will require clearing of the native revegetation on the shoulders and overhanging the road.

There are concerns that the proposed roundabout near to the old Rowley Road and Hilbert Road will cause some traffic safety issues if the second access is required.

This BMP is applicable to only the seven individual lots and not the remainder of Lot 9004.

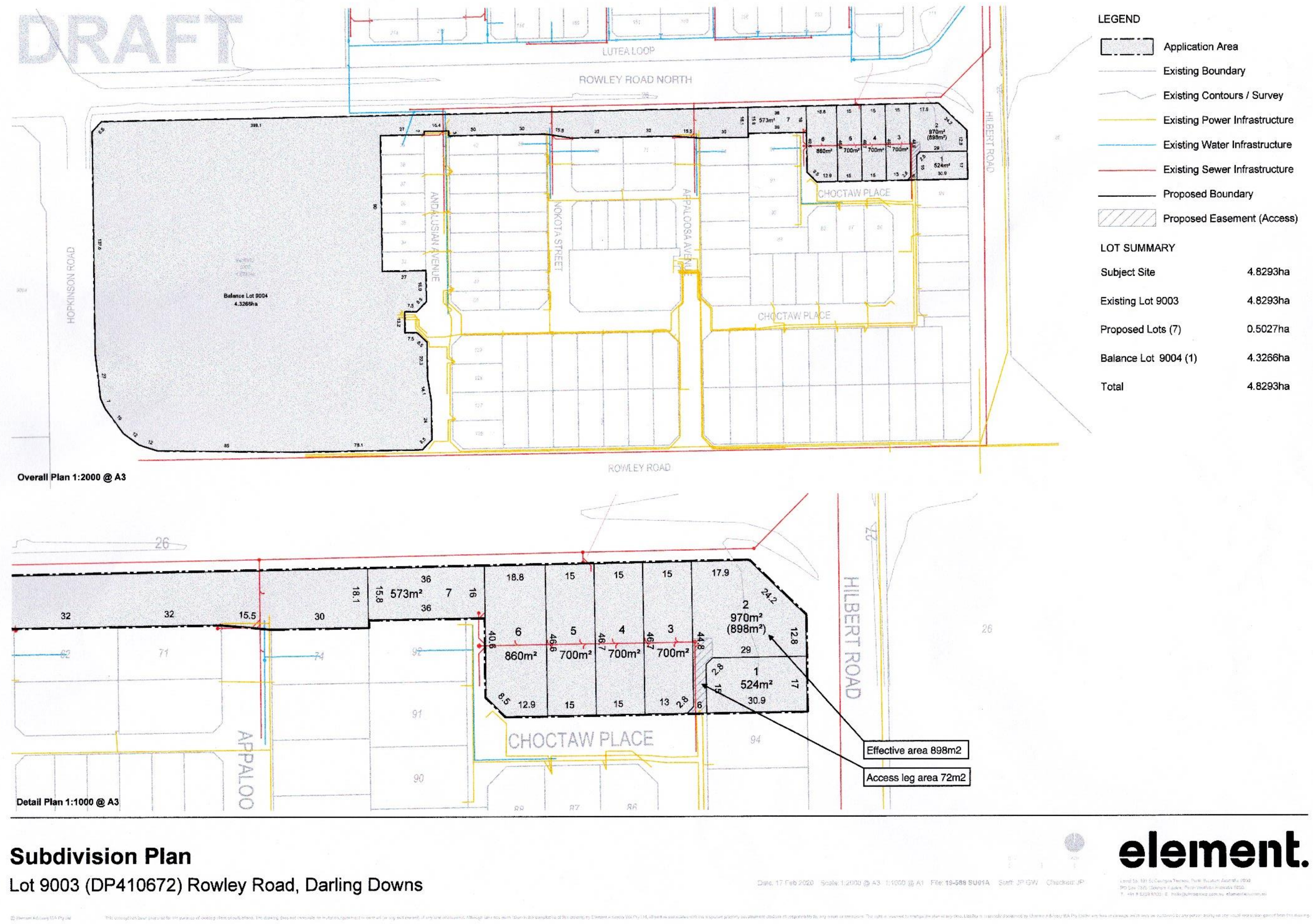


Figure 1. A copy of the site covered by this BMP.

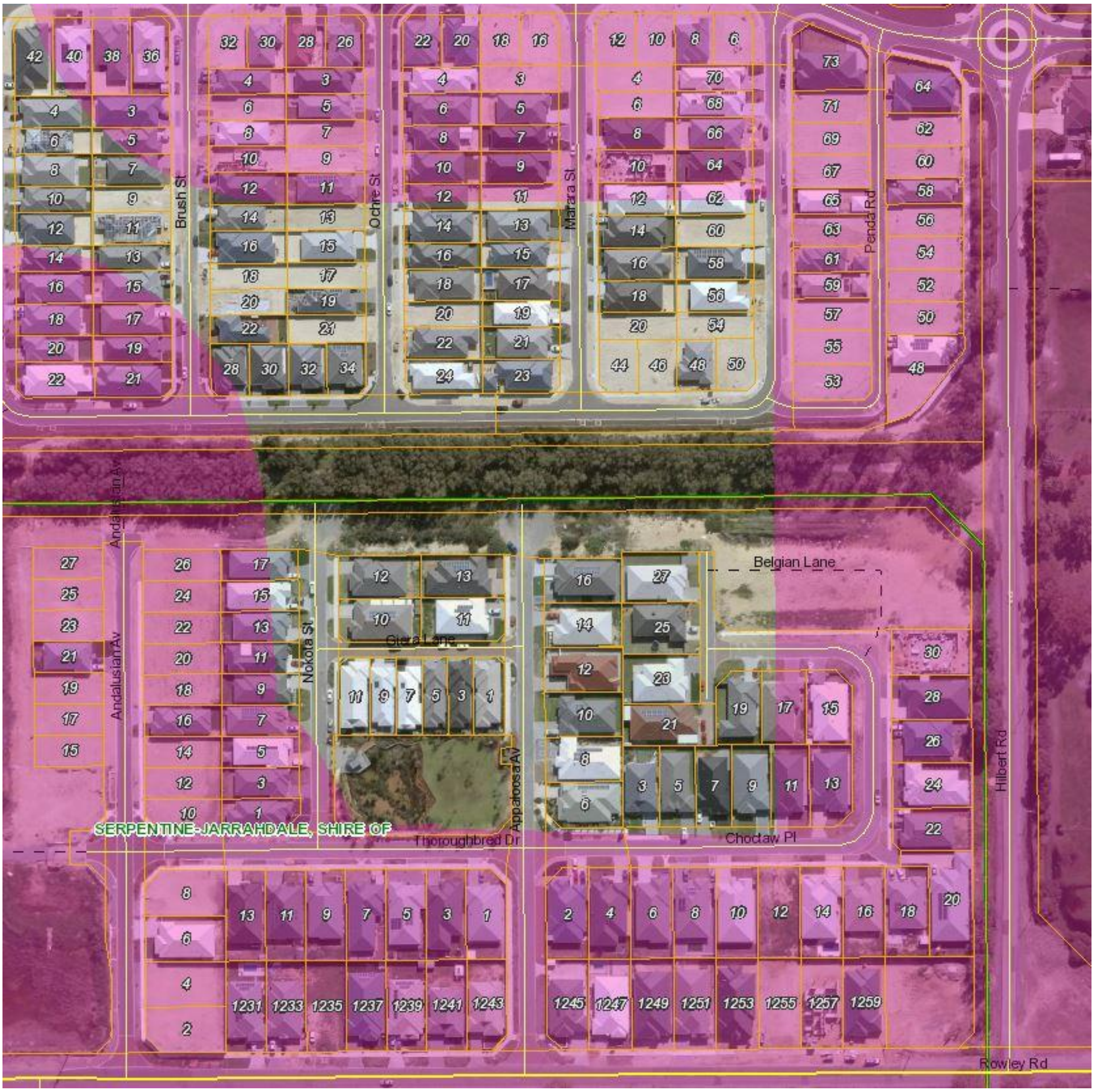


Figure 2. Screen shot of map of bushfire prone areas for the subject site.

It is noted that not all of the site is formally declared as bushfire prone. The declaration of the areas as bushfire prone is required to trigger AS 3959 through the Building Code of Australia (BCA).

Section 2: Environmental Considerations

Subsection 2.1: Native Vegetation – modification and clearing

There will not be a need to clear significant areas of overstorey native vegetation on the site as a component of this development. The site is effectively cleared of native species. There are areas of native species regeneration associated with the old Rowley Road that will be required to be cleared if the second alternative access option is required.

Subsection 2.2: Re-vegetation/Landscape Plans

There are no revegetation plans associated with the development. It is expected that when the lots are created, dwellings and gardens will be constructed.

Section 3: Bushfire Assessment Results

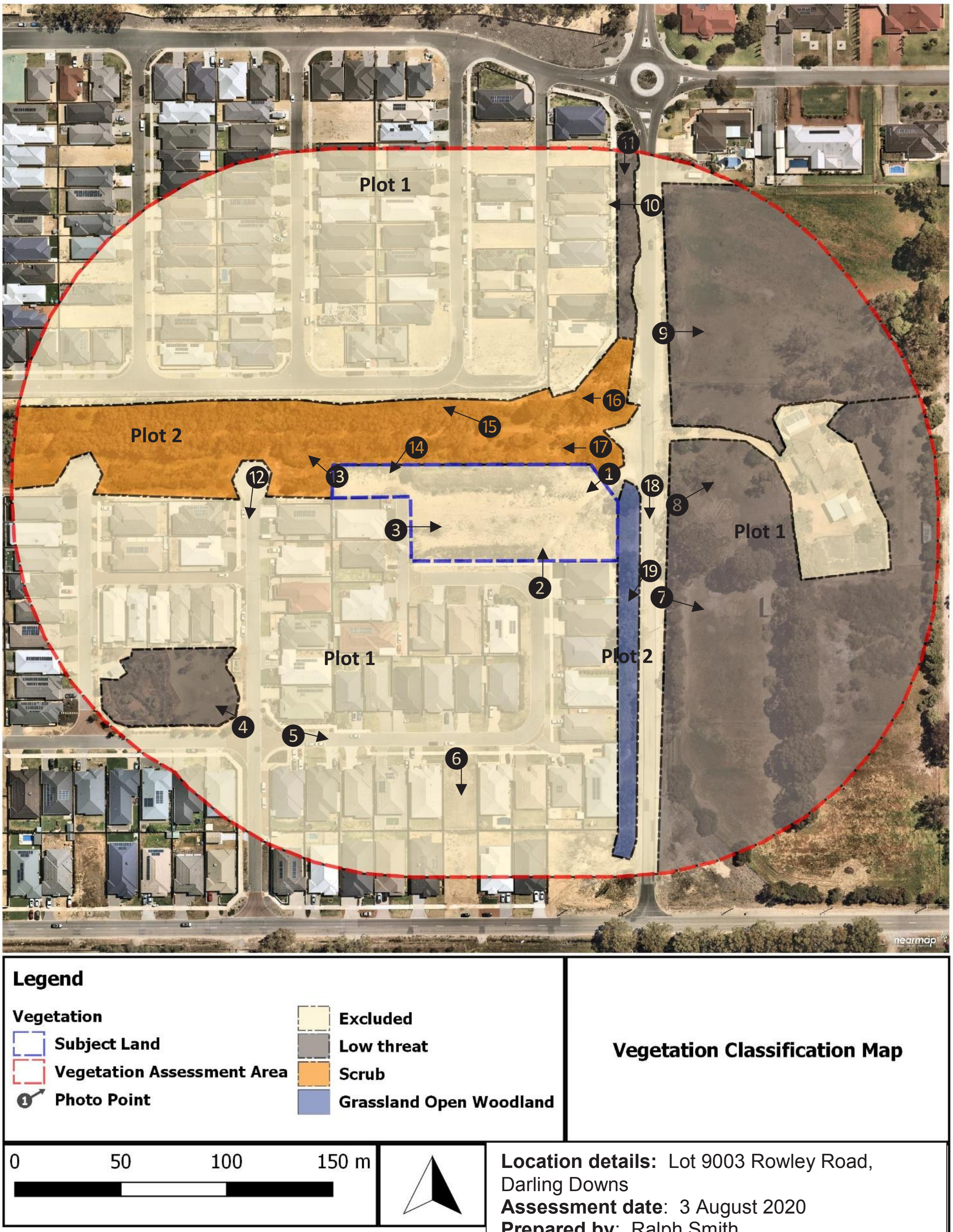
If the vegetation is removed adjacent to the old Rowley Road the BAL rating for the lots will be BAL–LOW.

Subsection 3.1: Assessment Inputs

The assessment inputs are shown in the forthcoming pages and are supported by a vegetation assessment, photographic evidence and text to support the vegetation assessment and a BAL Contour Map.

Site Assessment

The assessment of the proposed amendment was undertaken on 3 August 2020 for the purpose of determining the Bushfire Attack Level in accordance with AS 3959 (Method 1).



Location details: Lot 9003 Rowley Road, Darling Downs
Assessment date: 3 August 2020
Prepared by: Ralph Smith
Accreditation level: 2
Accreditation number: 27541
Accreditation expiry date: August 2021
Date aerial photo: May 2020

Figure 3. Vegetation Classification Map.

Subsection 3.1: Assessment Inputs

Vegetation Classification

All vegetation within 150 metres of the proposed development as indicated on the site assessment plan was classified in accordance with the Western Australian Government criteria and Clause 2.2.3 of AS 3959 was applied. Each distinguishable vegetation plot with the potential to determine the Bushfire Attack Level is identified below. AS 3959 only requires consideration of 100 metres between vegetation and the building and 50 metres for grassland.

Plot 1

Exclusion – Low threat vegetation and non-vegetated areas
Clause 2.2.3.2 (e) and (f)

Photo ID: Photo 1 Looking at the cleared site ready for the subdivision.

Photo ID: Photo 2 Looking north at the road reserve and infrastructure and the subdivision site.

Photo ID: Photo 3 Looking east at the subdivision site and associated infrastructure near the subdivision site.

Photo ID: Photo 4 Looking at the managed low threat vegetation south-west of the subdivision site.

Photo ID: Photo 5 Looking at the infrastructure and houses south of the subdivision site.

Photo ID: Photo 6 Looking at the managed grass on the vacant lots that are south of the subdivision site.

Photo ID: Photo 7 Looking at the horse paddocks and associated infrastructure east of the subdivision site.

Photo ID: Photo 8 Looking at the dwelling, sheds, cultivated garden and grazed grass.

Photo ID: Photo 9 Looking at the grazing paddock with horses east of the subdivision site.

Photo ID: Photo 10 Looking at the suburban infrastructure, dwellings and reticulated and cultivated gardens.

Photo ID: Photo 11 Looking at the reticulated and cultivated garden in the road reserve and dwellings.

Photo ID: Photo 12 Looking at the suburban infrastructure.

Plot 2

Class D – Scrub (AS 3959 classification D-13)

Photo ID: Photo 13 Looking at the regrowth scrub on the western boundary of the subdivision site.

Photo ID: Photo 14 Looking at the regrowth scrub vegetation and the old Rowley Road bitumen strip of road.

Photo ID: Photo 15 Looking at the regrowth scrub and grass surface vegetation which will be removed.

Photo ID: Photo 16 Looking at the regrowth and fence separating the development to the north and the vegetation.

Photo ID: Photo 17 Looking at the regrowth scrub and grass surface vegetation immediately north of the subdivision site on the old Rowley Road.

Plot 3

Class G – Grassland under an open canopy (AS 3959 classification G-06)

Photo ID: Photo 18 Looking at the grass under an open overstorey cover and road reserve. .

Photo ID: Photo 19 Looking at the grass and road reserve.

Notes to Accompany Vegetation Classification

1. Plot 1

Exclusion – Low threat vegetation and non-vegetated areas
Clause 2.2.3.2 (e) and (f)

This plot comprises the houses, sheds, gardens and infrastructure surrounding the subdivision site. The site is within an established suburb with all of the normal amenities such as roads, mains reticulated water, and other infrastructure. The land to the north is an established suburb with most available lots having a dwelling located on them. The lots not yet sold south of the subdivision site are all maintained in a low threat vegetation state as required under the Firebreak Order.

The photographs were taken during winter when there is no requirement under the Firebreak Order to maintain the grass to a reduced height. The tall grass will provide an impression of the grass being a potentially elevated bushfire threat.

Plot 2
Class D – Scrub (AS 3959 classification D-13)

This plot comprises the regrowth scrub vegetation associated with the old Rowley Road narrow bitumen road immediately to the north of the subdivision site. The old Rowley Road narrow bitumen road remains, but the vegetation has been permitted to regrow. This vegetation will be removed when the Rowley Road re-alignment occurs. This vegetation was classified as 'low threat vegetation' when the Bushfire Management

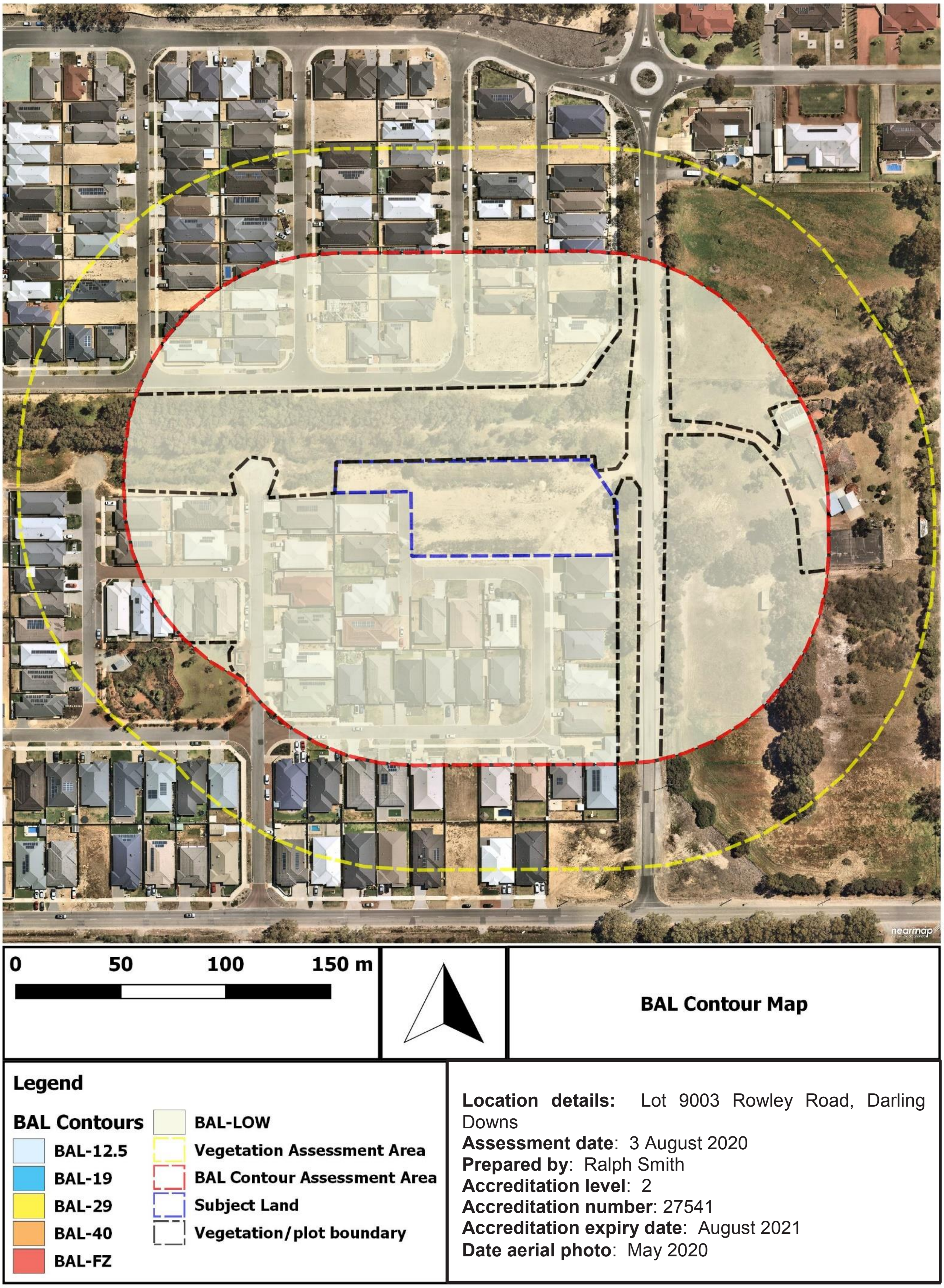
Plan was developed by Bio Diverse Solutions (8/8/2016) and the subdivision site is still not entirely classified as Bushfire Prone by the State Government.

Within Plot 2, which is currently classified as scrub, the proposal is to modify the scrub to 'low threat vegetation' as identified in AS 3959 section 2.2.3.2 (f). To achieve that 'low threat vegetation' classification it is necessary to remove the regrowth overstorey trees and manage the grassland surface vegetation.

Plot 3
Class G – Grassland under an open canopy (AS 3959 classification G-06)

This plot comprises the narrow strip of grassland under a sparse overstorey cover. This grassland is between nine and 11 metres wide. As the grassland strip is within 20 metres of the site it influences the BAL assessment and cannot be excluded under AS 3959 Section 2.2.3.2 (d).

The grassland adjacent to Hilbert Road within Plot 3 will be mown/slashed and maintained during the bushfire season at less than 100 mm in height. It will therefore comply with AS 3959 section 2.2.3.2 (f) and be classified as an Exclusion – Low threat vegetation and non-vegetated areas.



Location details: Lot 9003 Rowley Road, Darling Downs
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Date aerial photo: May 2020

Figure 4. BAL Contour Map.

Slope

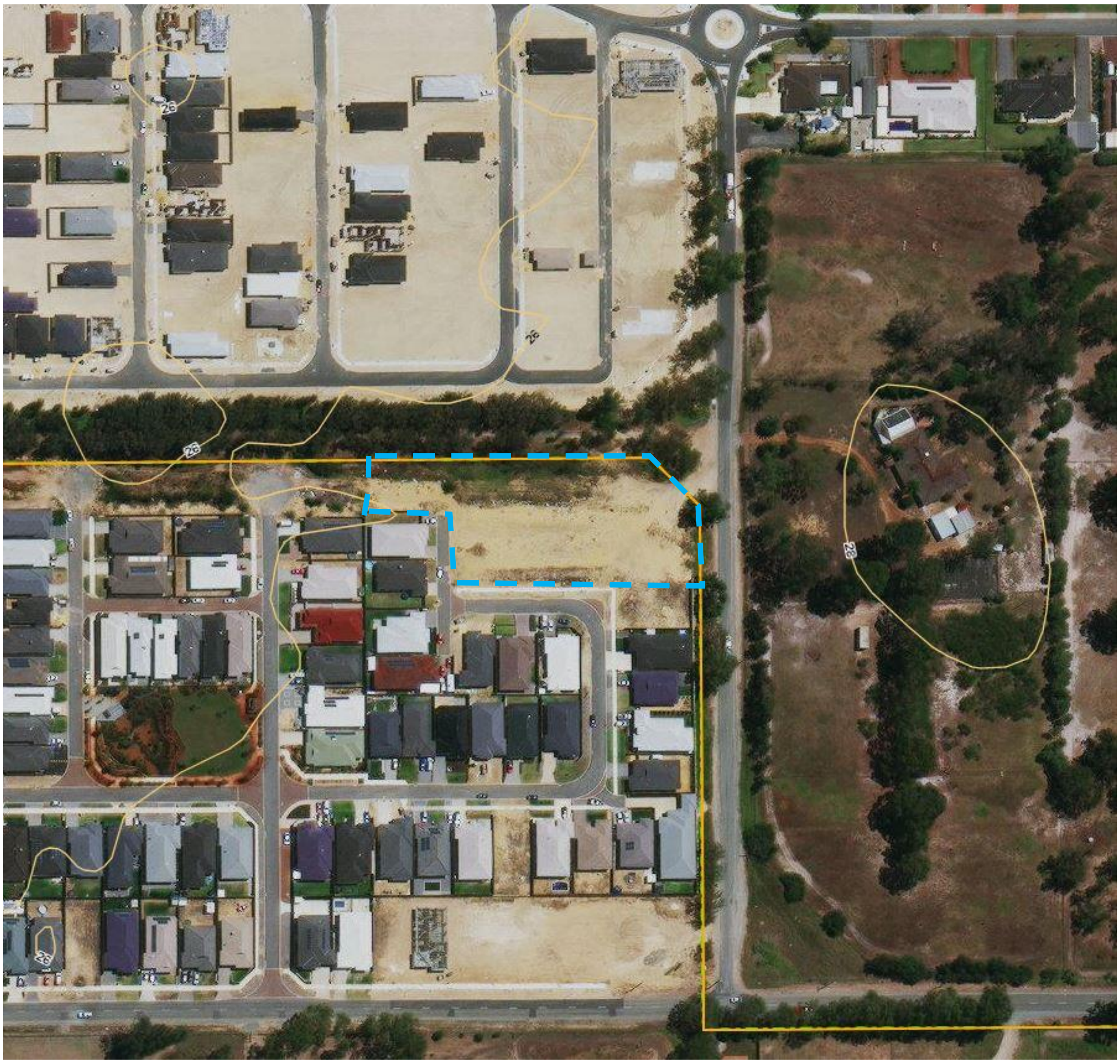


Figure 5. Two-metre contour map.

The slope is not a consideration with the BAL assessment with this development as the land is effectively flat.

Subsection 3.2: Assessment outputs

Potential Bushfire Impacts

The potential bushfire impacts to the proposed subdivision from each of the identified vegetation plots are identified below.

Plot	Vegetation Classification	Effective Slope	Separation distance (m)	BAL rating
1	Exclusion – Low threat vegetation and non-vegetated areas Clause 2.2.3.2 (e) & (f)	Not applicable	Not applicable	LOW
2	Class D – Scrub (AS 3959 classification D-13) – modified to 'low threat vegetation'	Flat	0	BAL–LOW
3	Class G – Grassland under an open canopy (AS 3959 classification G-06) – modified to 'low threat vegetation'	Flat	0	BAL–LOW

Determination of Bushfire Attack Level (BAL)

The determined Bushfire Attack Level (highest BAL) for the proposed subdivision has been determined in accordance with Clause 2.2.6 of AS 3959 using the above analysis. The analysis has not considered individual lot boundaries nor the specific location of the dwellings as these are not known.

The portion of the subdivision site where the lot is not declared as bushfire prone will not be influenced by the AS 3959 requirements.

The determined Bushfire Attack Level (BAL) is **BAL–LOW.**

Section 4: Identification of bushfire hazard issues

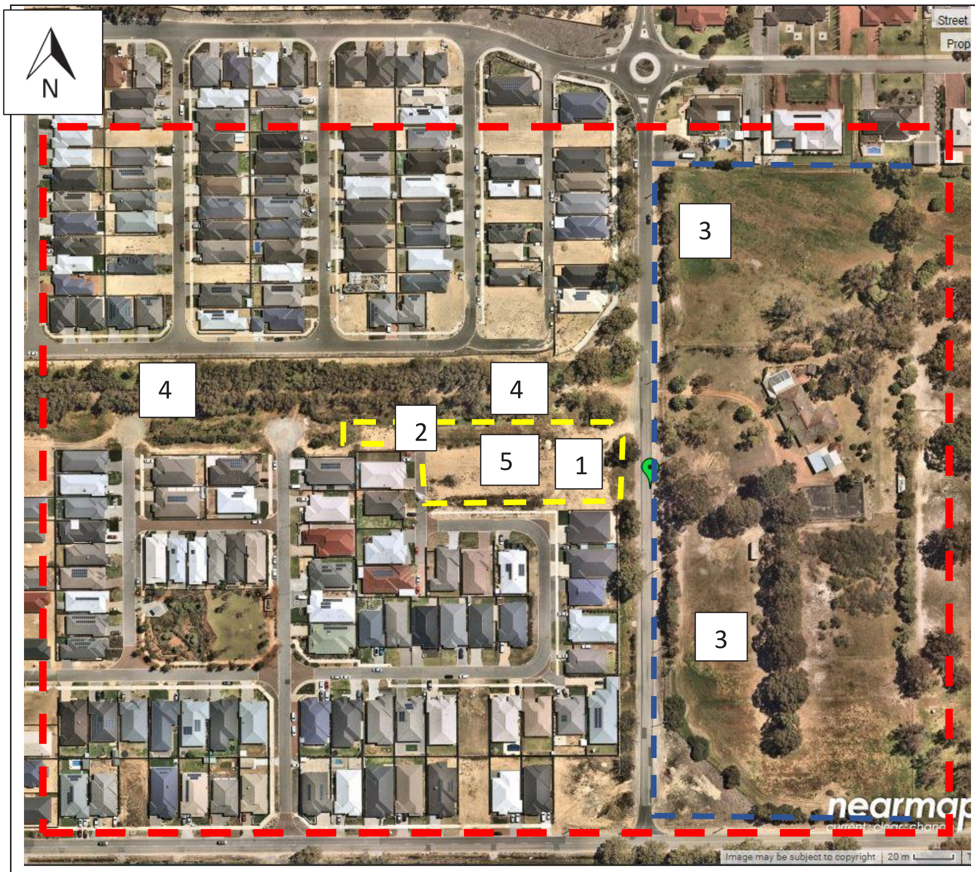
The most significant bushfire hazard is the extensive grassland associated with the land neighbouring the site. This grassland is well managed and pose a very low threat.

The regeneration scrub on the old Rowley Road will need to be removed to provide the EAW second access option if required by the decision maker.

Section 5: Assessment against the Bushfire Protection Criteria

Subsection 5.1: Compliance Table

Bushfire protection criteria	Method of Compliance	Proposed bushfire management strategies
	Acceptable solutions	
Element 1: Location	A1.1 Development location	Any future dwelling will be located in an area that is restricted to where the BAL rating will be BAL–29 or less.
Element 2: Siting and design	A2.1 Asset Protection Zone (APZ)	An APZ is not required.
Element 3: Vehicular Access	A3.1 Two access routes	The site is currently not serviced by two alternative access options. The entire site is not declared as bushfire prone.
	A3.2 Public road	Hilbert Road is constructed and bitumen.
	A3.3 Cul-de-sac (including a dead-end-road)	There are currently cul-de-sacs within the area and these provide access to the lots.
	A3.4 Battle-axe	Not applicable.
	A3.5 Private driveway longer than 50 m A private driveway is to meet detailed requirements contained within the Guidelines	Not applicable.
	A3.6 Emergency access way	There may be an EAW constructed to provide two alternative access options associated with the development. The EAW will be designed to restrict 'normal' traffic. This will only be developed if required by the decision makers.
	A3.7 Fire service access routes (perimeter roads)	Firebreaks will continue to be maintained in accordance with the Shire's firebreak order.
	A3.8 Firebreak width	Firebreaks will be maintained so as to comply with the Shire's firebreak order.
Element 4: Water	A4.1 Reticulated areas	The reticulated scheme water system services this area.
	A4.2 Non-reticulated areas	Not applicable.
	A4.3 Individual lots within non-reticulated areas (Only for use if creating 1 additional lot and cannot be applied cumulatively)	Not Applicable.



LEGEND

Subject land 🟨

Hazard vegetation 🟦

150m assessment zone 🟥

Sealed roads ▬

REQUIREMENTS

1. The site is serviced by reticulated scheme water supply.
2. Future EAW may provide alternative access options and may be in this location.
3. This is the principle hazard vegetation, being grassland and is a very low threat as it is grazed by horses.
4. This is scrub that will be removed.
5. The area not declared as bushfire prone does not require the dwellings to be built to AS 3959 standards.

Location details: Lot 9003 Rowley Rd, Darling Downs
Assessment date: 3/8/2020
Prepared by: Ralph Smith
Accreditation level: 2
Accreditation number: 27541
Accreditation expiry date: August 2021
Date aerial photo: May 2020
Version No: 1

Figure 6. Spatial representation of bushfire management strategies.

Section 6: General considerations for bushfire management

The following are the general considerations for bushfire management:

- The majority of the site and the neighbouring locations are a low to moderate hazard level.
- The regeneration within the old Rowley Road will be removed.
- If the EAW is required it will link to the old Rowley Road and then through to Hilbert Road.

Section 7: Responsibilities for Implementation and Management of the Bushfire Measures

DEVELOPER/LANDOWNER – PRIOR TO OCCUPANCY	
No.	**Implementation Action**
1	Install the driveway(s) to the standards stated in the Guidelines.
2	Install the required water supply that meets State's specifications.
3	A notification, pursuant to Section 165 of the *Planning and Development Act 2005* is to be placed on the certificate(s) of title of the proposed lot(s) within the formally declared Bushfire Prone Areas, advising of the existence of a hazard or other factor. Notice of this notification is to be included on the diagram or plan of survey (deposited plan). The notification is to state as follows: *"This land is within a bushfire prone area as designated by an Order made by the Fire and Emergency Services Commissioner and may be subject to a Bushfire Management Plan. Additional planning and building requirements may apply to development on this land".*
4	Clear the vegetation in Rowley Road (north) and install the EAW to provide the second access option if still required by the decision makers.

LANDOWNER/OCCUPIER – ONGOING MANAGEMENT	
No.	**Management Action**
1	Comply with the relevant local government annual firebreak notice issued under s33 of the Bush Fires Act 1954.

Appendix 1

Location of the EAW if it is required by the decision makers.

Appendix 2

Map showing the hydrant locations.

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Level 18, 191 St Georges Tce, Perth WA 6000
T. (08) 9289 8300 – **E.** hello@elementwa.com.au
elementwa.com.au